# FRDA Report 090

# Forest Regeneration in the ICHg, Prince Rupert Forest Region: A Problem Analysis

by
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## EXECUTIVE SUMMARY

This problem analysis was undertaken to identify the nature and extent of reforestation problems in the ICHg subzone in the Prince Rupert Forest Region. Data were obtained from four sources: questionnaire results from local foresters, Ministry of Forests history record reports, field sampling, and a literature review.

In the past, regeneration in this subzone has been inadequate. Ministry of Forests history records indicate that 23 380 ha of land denuded before 1986 remains not satisfactorily restocked. This large area represents an approximate annual loss in timber production of 88 844 $m^3$.

History record analysis revealed that planting, both with and without site preparation, yielded good results (86% and 85%, respectively). Planting in general was far more successful than reliance on natural regeneration: 83% of the areas planted after logging were satisfactorily restocked, compared to only 32% of all areas left for natural regeneration. Planting success also improved when planting was completed within 2 years after logging. Where natural regeneration was successful, western hemlock was the predominant species on site.

In the questionnaire, foresters rated poor treatment timing as the most important factor contributing to regeneration failure in the ICHg. Two other important factors were vegetation competition (fireweed, thimbleberry, hazelnut, rose, red osier dogwood, birch, aspen, and grasses) and a lack of experience and/or data necessary to prescribe sound treatments. The relative importance of these three factors was corroborated during field sampling. Other factors related to poor regeneration performance were:

- shallow soils in the ICHg1 and deep humus in portions of the ICHg3;
- sites with excessive moisture due to topographic position, soil compaction, or heavy textured soils;
- snow press associated with heavy herbaceous vegetation, particularly in the ICHg4 which is subject to heavy snow loading;
- low-impact site preparation which stimulate competing vegetation;
- logging activities requiring 2 or more years to complete, and resulting in poor broadcast burn impacts and less control of brush development; and
- a lack of adequate funding in the past.

Many foresters were also concerned about the future effects of *Pissodes strobi* and *Hylobius warrenii,* although no failures were attributed to these pests.

Management recommendations for the 10 most important factors contributing to reforestation failures are outlined in the report. In general, improved problem identification and planning at the pre-harvest and field survey stages should improve reforestation success.

Topics requiring future research in the ICHg are identified. The highest priority is determining the correlation among pre-harvest vegetation, silviculture treatments, and post-treatment vegetation.

## ACKNOWLEDGEMENTS

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# 1 INTRODUCTION

## 1.1 Scope

In the past, regeneration success has often been inadequate in the Northwest Transitional Subzone of the Interior Cedar Hemlock Biogeoclimatic Zone (the ICHg) in the Prince Rupert Forest Region. Although current practices, such as planting most cutover sites, using improved stock, and increased funding through the Canada - B.C. Forest Resource Development Agreement (FRDA) and the Small Business Enterprise Program (SBEP), have substantially improved regeneration success, Ministry of Forests history records show that 23 380 ha of land denuded through logging or wildfire before 1986 is still not satisfactorily restocked (NSR). Approximately 46% of this large area was disturbed through logging.

Terms of reference for the project were developed by the Northern Interior Technical Advisory Committee (NITAC). The project focused on determining the nature and extent of reforestation problems and identifying proven and potential solutions. Specific objectives were:

1. to determine which factors contribute to lack of regeneration success in the subzone;
2. to rank the relative importance of each factor;
3. to identify proven and potential methods for overcoming these factors;
4. to recommend research priorities for problems that have not been resolved; and
5. to communicate results to foresters working in the area.

## 1.2 Description of the Area

### 1.2.1 Location

The ICHg is a transitional area located between the Coast Mountains and Interior Plateau along the Bulkley, Kispiox, Skeena, Nass, Iskut, and Stikine rivers (Figure 1). The latitudinal range extends from 54° 40'N to 57° 30'N.

The subzone occupies valley bottom and mid-slope positions along these drainages. Topography and soil parent materials are variable, ranging from sedimentary bedrocks and fluvial deposits in the Nass basin to morainal and colluvial materials over granitic bedrock on the rugged slopes of the Hazelton mountains.

### 1.2.2 Climate and vegetation

Haeussler *et al.* (1985) have described climatic conditions and vegetation composition in the ICHg. Most of the following information was derived from this source and it is suggested that interested readers refer to it for more thorough coverage of the topic.

Compared to other ICH subzones, the study area has a colder climate because of its northerly latitude. Mean annual precipitation ranges from 500 to 1200 mm, and moderate to heavy snowpacks occur. Mean annual temperature is only 4.4°C. The mean daily minimum temperature in the coldest month is -13.9°C, and mean daily maximum temperature in the warmest month is 22.5°C.

The transitional nature of the climate and physiography in the area is reflected in its vegetation. Climax forests are dominated by western hemlock, with minor components of subalpine fir, hybrid spruce, and western redcedar. Seral stands of lodgepole pine, trembling aspen, paper birch, and spruce are common at lower elevations. Brush species, particularly shrubs, are vigorous and abundant, and include species common to both the interior plateau and coastal areas.

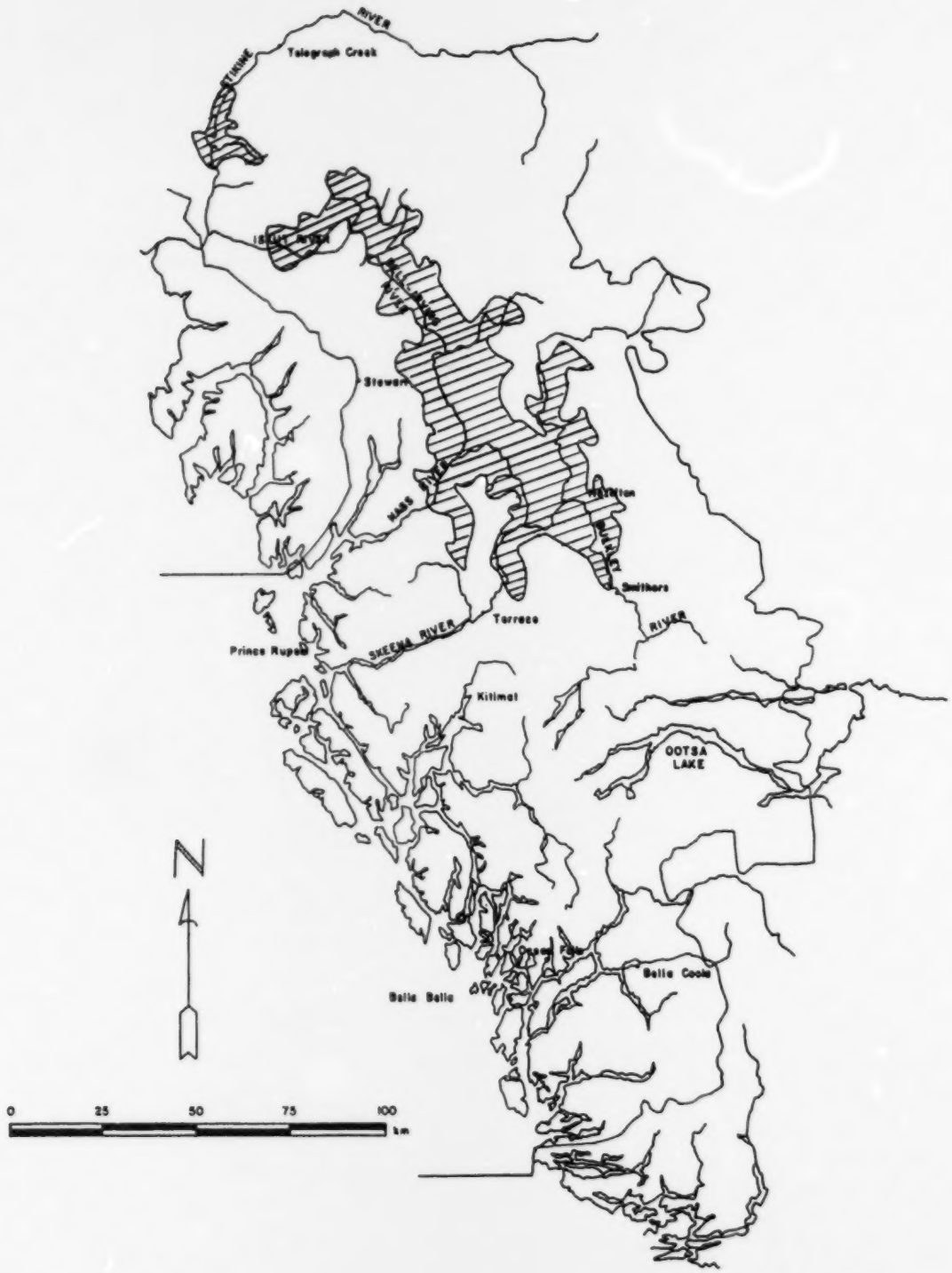


FIGURE 1. Location of the study area.

### 1.2.3 Logging and wildfire history

Significant logging activity is relatively recent in the ICHg. No major tenure holders operated in the area before 1966 (L. Bush, pers. comm., 1988). In fact, in the ICHg4 variant, major licenses were only issued as recently as 1986. In the ICHg5 variant there are no major license holders and Small Business activity has also been minimal. Historically, most logging activity has occurred along the valley bottoms and lower slopes of major drainages (ICHg 2, 3+1).

Wildfires have denuded 14 066 ha since 1911, occuring most commonly in the ICHg4 and 5. Since the early 1960's, all wildfires have received initial attack, with continued fire suppression when resource values were high and access available.

## 2 METHODS

Data were obtained from four sources: a questionnaire, Ministry of Forests history record reports, field observations, and a literature review. Note that all references to biogeoclimatic units in this document have been made using designations published before 1988 and are as follows:

ICHg1 - Upper Nass Basin variant

ICHg1a - Upper Nass Basin variant, Amabilis Fir phase

ICHg2 - Lower Nass Basin variant

ICHg3 - Hazelton variant

ICHg4 - Meziadin - Bell-Irving variant

ICHg5 - Iskut - Stikine variant

New designations have recently been published as a result of a correlation project conducted across the province in 1987 and 1988. The new designations for the ICHg are as follows:

ICHg1 and 1a - ICHmc2

ICHg2 and 3 - ICHmc3

ICHg4 and 5 - ICHvc

### 2.1 The Questionnaire

The aim of the questionnaire (Appendix 1) was to obtain from the perspective of 30 foresters and technicians who have worked in the area, a ranked list of the factors contributing to regeneration failures. Responses were received by telephone interview to ensure a better response rate and to ensure that questions were consistently interpreted. A cross-section of individuals (Appendix 2) was selected to ensure that industry, government, and consulting viewpoints were obtained and all five biogeoclimatic variants were represented (Appendix 3).

Data analysis was limited to summarizing the relative importance of each factor and identifying trends in treatment failures. The overall rating was obtained by averaging all respondents' rankings.

### 2.2 History Record Analysis

History records were used to provide a broader data base. Two types of special history record reports were obtained from Silviculture Branch: a District Status Report for Denuded Areas (one-time report 504) summarizing stocking status for all disturbed areas by District, and a Logging and Treatment Summary Report (one-time report 290).

From the District Status Report, areas of NSR and Satisfactorily Restocked (SR) were summarized and presented as a proportion of total disturbed area. For the purposes of this analysis, SR meant

greater than 699 well-spaced, acceptable trees per hectare. Openings were only used if the allowable regeneration delay period specified in Silviculture Manual Insert No. 11 (B.C. Ministry of Forests, PRFR, 1988) had been exceeded (backlog sites only). Mesic and drier sites harvested pre-1983, and moist ecosystems, harvested pre-1986, exceeded the allowable regeneration delay period and were included in the analysis.

Logging and Treatment Summary Report 290 was analyzed for relationships between regeneration success and treatment regime.

Only areas with complete history record information were analyzed. This amounted to approximately 17 000 ha. Most of the areas could not be analyzed because:

- stocking status information was incomplete;
- no survey information was available;
- the area was less than 2 ha; or
- treatment history could not be reconstructed because it was impossible to ascertain in which part of the opening successive treatments were conducted.

No wildfires were included in the analysis because survey information for them rarely existed.

### 2.3 Field Sampling and Analysis

Field sampling was used to assess reforestation problems in the ICHg. Thirty-five sites were selected based on the history record review and suggestions from questionnaire respondents (Table 1).

TABLE 1. Number of field sites inspected

| District | ICHg1 & 1a | ICHg2 | ICHg3 | ICHg4 | ICHg5 | TOTAL |
|---|---|---|---|---|---|---|
| Kalum | 7 | 1 | - | 5 | - | 13 |
| Kispiox | 2 | 4 | 10 | - | - | 16 |
| Bulkley | 1 | - | 1 | - | - | 2 |
| Cassiar | - | - | - | - | 4 | 4 |
| **TOTAL** | 10 | 5 | 11 | 5 | 4 | 35 |

Sites were chosen to represent common reforestation problems or successful treatment techniques. The aim of field sampling was to find explanations for more common regeneration problems and to verify the history records.

Within each opening, a small area (~1 ha) was chosen which typified conditions in the block and had relatively uniform site conditions. Site characteristics in this area were recorded on a field card developed by the consultant (Appendix 4).

### 2.4 Literature Review

Relevant literature was reviewed (1) to determine if other workers were finding similar reforestation problems in the ICH and (2) to fill information gaps. Three separate reforestation problem analyses (Butt and Bancroft [1]; Mather [2]; Still *et al.* [3] ) were particularly helpful.

### 2.5 Data Limitations

Because no statistical measure of data reliability has been provided in this study, some caution must be exercised in interpreting data. The following points are provided to show where the data base is weak.

Questionnaire Results:

1. Rankings were established for each factor by subzone, although a respondent's experience was often limited to only some of the variants. Where appropriate, these differences have been identified and discussed.
2. Factors were weighted equally, although the contribution of one factor to NSR could be much more important in one area or site type than in another. Snow press, for example, is a very important factor in the ICHg4, but of little consequence in the ICHg3.

History Records:

1. Total NSR figures from history record one-time report 540 are not very reliable on old burns or logging disturbance prior to 1962, where no recent survey information exists. A recent study in the Prince George Region [4], showed that a high percentage of similar areas there have regenerated naturally.
2. As previously stated, only 17 000 ha of openings in History Record Report 290 could be used because of missing information elsewhere in the records. Even the 23% used might be unreliable because survey standards, stocking standards, and species acceptability were different in the past to what they are now. However, because 96% of all disturbances included in the analysis occurred after 1979, the data were assumed to be within acceptable limits of reliability.

Field Data:

1. Stocking levels were estimated by eye only.
2. Plots were established on a non-random basis in areas chosen as representative.
3. Insufficient plots were established to perform statistical tests

Empirical data were collected mainly to ensure that the researcher considered all site conditions before ascribing reasons for regeneration results.

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1 Butt, G. and B. Bancroft. 1988. Silvicultural practices and forest regeneration in the ICH Zone in the Clearwater and Horsefly Forest Districts: a problem analysis. Unpubl. report. FRDA Project 3.47.

2 Mather, J. 1988. Assessment of silvicultural practices used in the Interior Cedar Hemlock Zone of the southern interior, ICHm2, b, and v subzones, Salmon Arm, Vernon, and Revelstoke Districts. Unpubl. report. FRDA Project 3.47.

3 Still, G., S. Thompson, and G. Utzig, 1988. ICH problem analysis, backlog silvicultural problems. Southern region - ICHa2, ICHa1, ICHb. Unpubl. report. FRDA Project 3.47.

4 T.M. Thompson and Associates Ltd. 1988. Dawson Creek/Fort St. John Inventory Audit. Unpubl. report.

# 3 RESULTS AND DISCUSSION

## 3.1 Magnitude of the Reforestation Problem

Between 1911 and 1982, total productive area disturbed from logging and wildfire in the ICHg is 35 801 ha, of which 65% (23 380 ha) is currently classified in the history records as backlog NSR. Table 2 shows total NSR by District and type of disturbance.

TABLE 2. Stocking status on disturbed backlog areas in the ICHg by District and source of denudation

| District | Source of Denudation | SR (ha) Planted | SR (ha) Natural | NSR (ha) | Total (ha) |
|---|---|---|---|---|---|
| Bulkley | logging | 901 | 5 | 395 | 1301 |
| | wildfire | 599 | 0 | 63 | 662 |
| Kispiox | logging | 6758 | 1736 | 6731 | 15225 |
| | wildfire | 0 | 200 | 2950 | 3150 |
| Kalum | logging | 1215 | 228 | 3718 | 5161 |
| | wildfire | 0 | 608 | 626 | 1234 |
| Cassiar | logging | 0 | 32 | 16 | 48 |
| | wildfire | 0 | 139 | 8881 | 9020 |
| TOTALS | logging | 8874 | 2001 | 10860 | 21735 |
| | wildfire | 599 | 947 | 12520 | 14066 |

Note that 72, 44, 33, and 30% of disturbed areas logged pre-1982 in the Kalum, Kispiox, Cassiar, and Bulkley Districts, respectively, have **not** been satisfactorily restocked. In the Cassiar District most areas classified as NSR are where wildfires have occurred but never been surveyed or managed. Recent surveys in one Cassiar fire show that up to 30% of the area has sufficiently regenerated through natural seed-in. Actual NSR in this District may, therefore, be considerably lower.

Notwithstanding potentially lower NSR levels in fires, the high level of NSR in the ICHg must be viewed as a major problem. Based on an average mean annual increment per hectare of 3.8 $m^3$, the annual loss in timber production in this NSR land (currently not included in the AAC) would be approximately 88 844 $m^3$. [5]

## 3.2 History Record Correlations: Reforestation Success by Treatment History

Relationships between treatments and regeneration success are summarized in this section. Summaries are presented by groups of variants that correspond to the new biogeoclimatic designations (see Section 2). Each summary is based on all openings in the history record system for which current survey information is available: approximately 17 000 ha of the total disturbed area in the ICHg. The data set for the ICHg4 and 5 is small, however, because of the historical lack of logging or silviculture in the area. This limits analysis in these variants.

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5 Derived from an average species mix of 50% hemlock, 27% balsam, 15% spruce, 5% pine, and 3% cedar (from the 1988 TSA analysis, Forest Inventory Zone J) and average MAI derived from Richards/Chapman volume over age equations.

Table 3 summarizes the extent and success of silviculture treatments in the ICHg.

TABLE 3. Summary of silviculture treatments used in the ICHg by variant

| Treatment | ICHg 1 and 1s | | | | ICHg 2 and 3 | | | | ICHg 4 and 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area treated (ha) | % of total area | SR % | NSR % | Area treated (ha) | % of total area | SR % | NSR % | Area treated (ha) | % of total area | SR % | NSR % |
| log | 400 | 10 | 47 | 53 | 4 368 | 35 | 34 | 66 | 675 | 84 | 12 | 88 |
| log, plant Pl | 1 092 | 28 | 97 | 3 | 1 160 | 9 | 81 | 19 | - | - | - | - |
| log, plant Sx | 1 185 | 30 | 81 | 19 | 2 482 | 20 | 84 | 16 | 103 | 13 | 78 | 22 |
| log, burn | - | - | - | - | 199 | 2 | 62 | 38 | - | - | - | - |
| log, burn, plant Pl | 148 | 4 | 89 | 11 | 81 | 1 | 90 | 10 | - | - | - | - |
| log, burn, plant Sx | 703 | 18 | 88 | 12 | 1 136 | 9 | 79 | 21 | - | - | - | - |
| log, MSP | - | - | - | - | 64 | 0 | 100 | - | - | - | - | - |
| log, MSP, plant Pl | 49 | 1 | 100 | - | 456 | 4 | 82 | 18 | - | - | - | - |
| log, MSP, plant Sx | 187 | 5 | 100 | - | 271 | 2 | 80 | 20 | 22 | 3 | - | 100 |
| log, brush | - | - | - | - | 609 | 5 | 85 | 15 | - | - | - | - |
| log, plant Pl, brush | 27 | 1 | 100 | - | 191 | 2 | 80 | 20 | - | - | - | - |
| log, plant Sx, brush | 122 | 3 | 100 | - | 347 | 3 | 81 | 19 | - | - | - | - |
| log, burn, plant Pl, brush | - | - | - | - | 193 | 2 | 100 | - | - | - | - | - |
| log, burn, plant Sx, brush | - | - | - | - | 606 | 5 | 95 | 5 | - | - | - | - |
| log, MSP, plant Sx, brush | - | - | - | - | 28 | 0 | 100 | - | - | - | - | - |
| log, burn, brush | - | - | - | - | 152 | 1 | 100 | - | - | - | - | - |
| TOTAL | 3 913 | 100 | N/A | N/A | 12 342 | 100 | N/A | N/A | 800 | 100 | N/A | N/A |

### 3.2.1 ICHg1 and ICHg1a: trends in the history record data base

Approximately 28% of disturbed land in the ICHg1 and 1a received some type of site preparation, but with little influence on regeneration success. In a similar range of ecosystem associations, 90% of all area in openings that had been site-prepared before planting was SR, and 89% of all area that had been planted without site preparation was SR. However, because areas that were site-prepared were subsequently planted, no conclusions on the effects of site preparation on natural regeneration can be drawn.

The most common method of site preparation conducted in the ICHg1 and 1a has been broadcast burning (79%). The only type of mechanical site preparation has been V-plowing. All six areas treated this way were satisfactorily regenerated.

Ninety percent of the disturbed areas in the ICHg1 and 1a are planted (Figure 2). This represents a higher proportion of sites than other variants and probably reflects the recent increase in planting in the Meziadin area. Relationships related to planting in the ICHg1 and 1a are clearer than those for site preparation. Not surprisingly, reforestation success increased with planting. On average, 89% of the areas planted were successfully regenerated, compared to only 47% of the areas left for natural regeneration. Little variation in this trend was noted in the three Districts.

Plantation survival in the ICHg1 and 1a has been excellent - an average of 89%. High survival rates can be partly attributed to the fact that most of the planting in these variants has been conducted since 1980, with better stock, better handling, and better micro-site selection than was available in the past.

Spruce (63%) and lodgepole pine (37%) are the only tree species operationally planted in the ICHg1 and 1a. Although spruce is the species planted on more ecosystem associations than pine (B.C. Ministry of Forests, PRFR, 1988), the latter has a greater survival rate (97% vs 81%, respectively). The reason is that pine is usually planted on submesic and drier sites, which are associated with less brush competition; while spruce is planted on mesic and wetter sites, which have higher brush competition (Haeussler *et al.* 1985).

Natural regeneration has a high failure rate (53%). Where natural regeneration was successful, western hemlock was the most abundant species (Figure 5). It is the dominant seed source available in the ICHg1 and 1a, accounting for 50% of total available volume in the three Timber Supply Areas (TSA). As well, it is a more prolific seeder than spruce or pine, and its seed carries a long way, germinating and surviving on a wide variety of seedbeds (Ruth and Harris 1979).

Both pine and spruce require a more particular set of conditions for successful seed-in. They were the less abundant species in naturally regenerated areas (10% and 5%, respectively). Western hemlock seedlings commonly occur as advance regeneration, but spruce and pine seedlings are sparse before logging.

Historically, little brush control has been conducted in the ICHg1 and 1a (~149 ha treated) and, therefore, no obvious trends were apparent in the history record data base. The foresters who responded to the questionnaire, however, considered brush to be a major contributor to NSR.

### 3.2.2 ICHg2 and ICHg3: trends in the history record data base

The area in which site preparation has been conducted in these variants is summarized in Table 3. Approximately 26% of the area disturbed by logging received site preparation, and 88% of that was followed by planting. As in the ICHg1, broadcast burning was the most common method (Figure 2), accounting for 64% of all site preparation conducted. A substantial area was also prepared mechanically (791 ha), 75% by V-plow. Field observations indicated that slash was large and frequently in heavy concentrations, thus necessitating this type of larger equipment (or burning). Success is not substantially different when sites are prepared before planting than when they are planted without site preparation (80% vs. 83%)(Table 3).

Only half of the disturbed area in the ICHg2 and 3 has been planted (Figure 3). This is probably because logging occurred early when less emphasis was placed on planting. Planting has increased reforestation success. Eighty-two percent of areas planted are currently satisfactorily restocked, but only 34% of areas left for natural regeneration. Plantation success was highest when planting occurred within 2 years of logging (Figure 6).

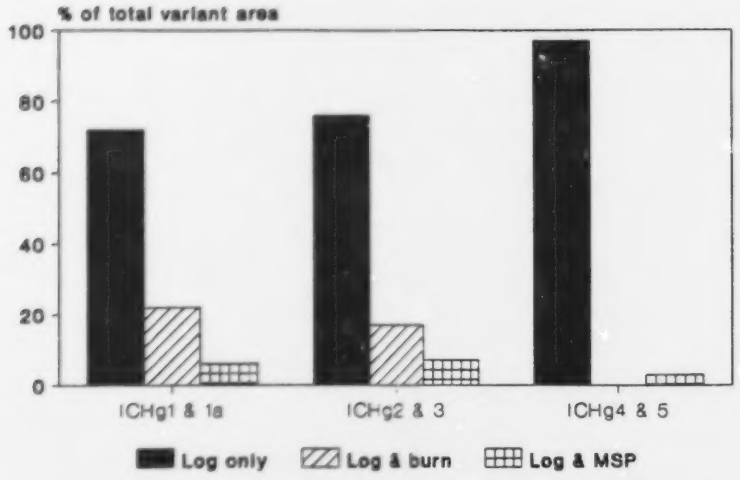


FIGURE 2. Site preparation method by variant.

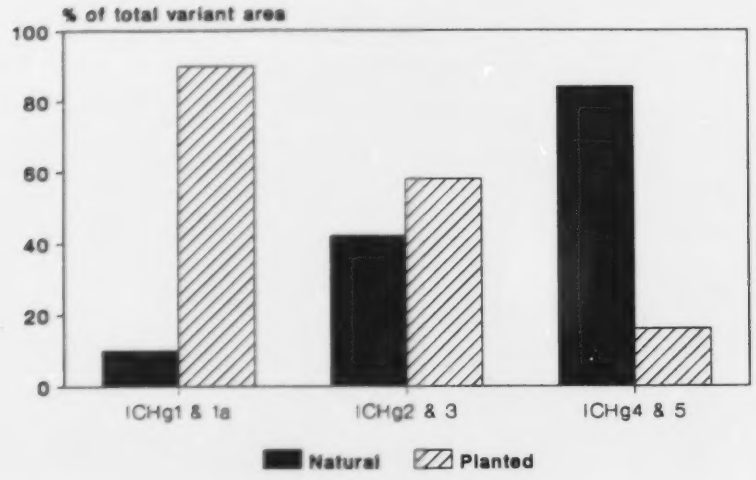


FIGURE 3. Regeneration method by variant.

Spruce was planted in 69% of openings but was less successful than the other species planted, lodgepole pine (31%) (Figure 4). Spruce is more difficult to establish than lodgepole pine although it is preferred on the mesic and moister sites which are associated with higher brush competition (B.C. Ministry of Forests, PRFR 1988).

Where natural regeneration was successful, western hemlock (58%) and lodgepole pine (25%) were the most abundant species (Figure 5).

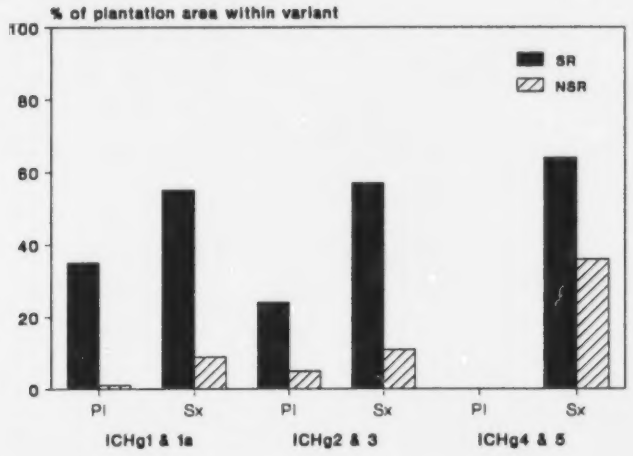


FIGURE 4. Species planted by stocking status.

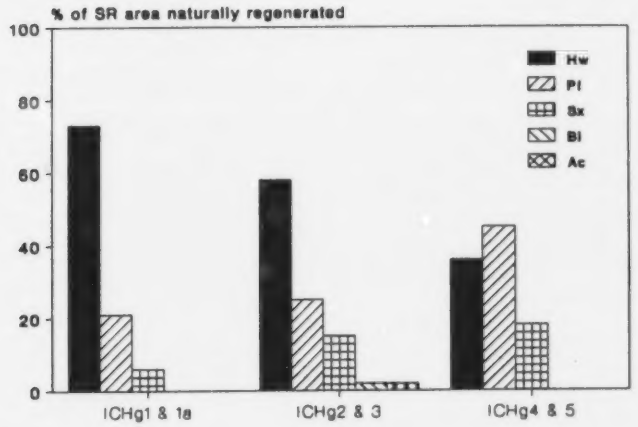


FIGURE 5. Natural regeneration by leading species.

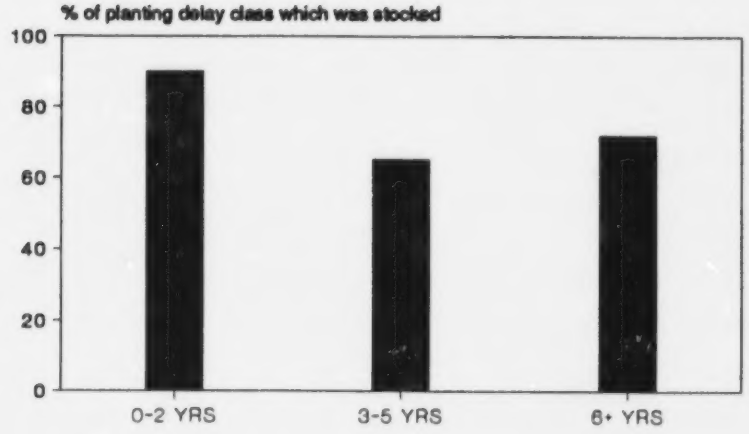


FIGURE 6. Planting delay after logging by stocking status for the ICHg2 and ICHg3.

Brush treatments were more prevalent in the ICHg2 and 3 than in other variants. Brushing was conducted on 17% (2125 ha) of total disturbed area. Of the areas receiving brushing, 89% were SR. Usually brushing occurred more than 6 years after logging – a treatment delay that is normally far too long since species such as fireweed and thimbleberry compete with crop trees within 1 year of planting (DeLong 1988).

### 3.2.3 ICHg4 and ICHg5: trends in the history record data base

Seventy-seven percent of the area logged in these two variants is NSR. Silviculture activities have been undertaken on only 16% of total area logged, indicating again that natural regeneration is often a poor method of reforestation. Relationships between site preparation and reforestation success were difficult to detect because only 1 opening of the 16 in the history records had been treated.

Although only 16% of the area disturbed has been planted (Figure 3), the planting has increased reforestation success significantly (78%). Compared to that for other variants, this success rate is relatively low and may be attributed primarily to poor stock quality (G. Parnell, pers. comm., 1988). On the other hand, only 12% of the area left for natural regrowth has successfully regenerated. However, this extremely low rate may simply be due to the fact that few older openings have had recent surveys and, therefore, complete data are unavailable. Again, as in other variants, western hemlock and lodgepole pine were the most common leading species on successful naturally regenerated sites.

## 3.3 Factors Contributing to Reforestation Failures

Foresters identified silviculture timing, shrub and hardwood competition, and lack of experienced personnel to be the most important factors contributing to NSR (Table 4). Field sampling showed vegetative competition, moisture levels, and lack of natural regeneration to be the most important factors

TABLE 4. The relative importance of factors contributing to reforestation problems in the ICHg: questionnaire results

| Factor | Rank |
|---|---|
| Treatment timing | 1 |
| Shrubs | 2 |
| Hardwoods | 3 |
| Experience of personnel | 4 |
| Logging scheduling | 5 |
| Budget | 6 |
| Stock quality | 7 |
| Silviculture impact | 8 |
| Herbs | 9 |
| Stock type | 10 |
| Logging method | 11 |
| Planting schedule | 12 |
| Moisture level | 13 |
| Snow press | 14 |
| Humus depth | 15 |
| Insects | 16 |
| Resource use conflicts | 17 |
| Soil texture | 18 |
| Aspect | 19 |
| Soil depth | 20 |
| Natural regeneration | 21 |
| Slope | 22 |
| Elevation | 23 |
| Animals | 24 |
| Product objectives | 25 |
| Other conifers (competition) | 26 |
| Nutrient status | 27 |
| Frost pockets | 28 |
| Disease | 29 |

Natural regeneration which was shown to be an important factor during field sampling, was not ranked as highly by foresters in the questionnaire. This subject reflects the current emphasis on planting: in the Ministry of Forests' Small Business program, up to 90% of current logging in the ICHg is expected to be planted (A. Germain and B. Wilson, pers. comm., 1988). Industry foresters also expect to plant in excess of 90% of logged areas (D. Tuomi, R. Goertzen, and T. Walgren, pers. comm., 1988).

### 3.3.1 ICHg1 and ICHg1a: analysis of factors

#### Site Factors

**Soils** Soils were generally not a major factor in causing NSR (Table 5), although in some areas (the upper Kispiox River, Meziadin River, and Van Dyke camp areas), regeneration difficulties were attributed to shallow, rapidly drained soils which make planting difficult and reduces water availability for seedlings. Such sites are also usually associated with thin humus layers. Humus is important on rocky, rapidly drained soils to provide much of a seedling's

nitrogen supply and aid in moisture retention (Feller 1983, Utzig and Walmsley 1988). Several foresters reported that drought, particularly in the Van Dyke area, had resulted in plantation failure.

TABLE 5. Importance of factors causing NSR: field data summary

| Factor | Rank |
|---|---|
| Vegetation competition | 1 |
| Moisture levels | 2 |
| Natural regeneration | 3 |
| Experience of personnel | 4 |
| Snow press | 5 |
| Stock quality | 6 |
| Silviculture treatment impact | 7 |
| Cold air ponding | 8 |
| Cold soils | 9 |
| Rodents | 10 |

Excessive moisture, however, was also a factor identified in causing NSR on these sites. Topographic position, compaction, and heavy textured soils such as clay loams reduced soil aeration. In areas of mechanical site preparation, rutting and compaction compound the drainage problem. In treating such problems on these sites, several foresters have established mounding trials. Although it is too early for conclusive results, preliminary results of a mounding trial established by A. Macadam (pers. comm., 1988) in the ICHg1 in 1987, indicate good initial survival.

Excessive moisture is also a problem on sites along the Nass bottomlands subjected to periodic flooding. Although flooding during the dormant season is relatively unimportant (Kozlowski 1986), floods along the Nass regularly extend well into June and can cause plantation failure. Studies conducted by Skeena Cellulose Inc. [6] and the North Coast District [7] indicate that the establishment of black cottonwood (*Populus balsamifera* var. *trichocarpa*) either naturally or artificially on active flood plains can increase plantation success and should be considered as an alternative to conifer species on such sites.

**Climate** Heavy snow loading was another factor felt to contribute to a lack of regeneration success on some sites. It resulted in such damage as stem deformation and bending and, in older stands, occasional breakage. This kind of damage is most commonly associated with moderately heavy cover of tall herbaceous species such as *Epilobium angustifolium*. Snow press is especially important on burned sites since burning promotes fireweed (Hamilton and Yearsley, 1988). Although seedlings appear to recover from snow press (R. Goertzen, pers. comm., 1988), no studies have been undertaken to define what they can endure or how well they can recover.

6 Davies, D. and A. Gottesfeld. 1987. Site selection criteria for black cottonwood on the Nass and Skeena River floodplains with management interpretation. Skeena Cellulose Inc. Unpubl. report.

7 McCulloch, L. 1985. Forest management plan for the lower Skeena River. B.C. Ministry of Forests, North Coast District. Unpubl. report.

Cold air ponding was not rated as an important factor in causing NSR in the questionnaire, although lack of knowledge in field identification techniques could be part of the reason. Foresters reported that cold air ponding occurs in the Nass River Valley bottom and in the Nass Valley on broken terrain. Coldest temperatures are found in shallow bowls where little radiation is reflected from adjacent stands or valley sidewalls (Mahrt 1985). The most severe frost conditions occur within the first few inches of the soil surface (Emmingham 1985), so frost tolerance during initial establishment is critical to regeneration success. Foresters have noted that planted spruce initially suffers from frost damage because of poor acclimatization of the stock (D. Coates, pers. comm., 1989). Spruce is the species most frequently planted on cold air ponding sites, and suffers frost damage on leaders and lateral shoots.

Cold air ponding is also associated with cold soil temperatures, which causes poor root growth and low rates of photosynthesis, resulting in poor seedling survival and performance.

**Pests** Although the collected data gave no sign that pests were a significant factor in causing NSR, many foresters interviewed felt that pests were a growing problem. The effect of the most common forest pests in the ICHg (*Pissodes strobi* and *Hylobius warrenii*) is not normally apparent until a forest is at a free-growing age (W. Martin, pers. comm., 1988). Most areas included in this study were too recently disturbed to have reached this age.

*Pissodes strobi* (spruce leader weevil) may have greater impact in the future. Areas stocked with infected trees are considered NSR by the Ministry of Forests. At present this pest is a severe problem in the CWH, and populations are moving north and east along river drainages towards the ICHg (W. Martin, pers. comm., 1988).

Another insect that is causing concern is the root collar weevil (*Hylobius warrenii*), whose populations seem to be building, particularly in young pine stands in the Kispiox District. Several foresters have expressed concern that future losses to this insect could be significant. The pine shoot moth (*Rhyacionia* spp) has also caused concern, primarily in the Cranberry River area.

### Vegetation Factors

Vegetation competition was identified as one of the most important factors in causing NSR in the ICHg (Table 4). It does so through vegetation press and light and seedbed competition.

The most important competitors are fireweed (*Epilobium angustifolium*), thimbleberry (*Rubus parviflorus*), red osier dogwood (*Cornus sericea*), and birch (*Betula papyrifera*). The distribution and abundance of these species is related to three factors: soil moisture regime, type and degree of site disturbance, and treatment scheduling.

**Soil moisture regime** Soil moisture is often the most important factor affecting abundance and growth of competing brush (Haeussler and Coates 1986). On submesic sites, brush development is generally low, although deciduous trees can occasionally cause problems (Haeussler *et al.* 1985).

On mesic sites, fireweed, thimbleberry, aspen, and birch are the main competitors. The same species occur on subhygric sites, but are larger and more abundant. Red osier dogwood and black cottonwood also occur there. The former is especially prominent on bottomland sites where treatment has been delayed more than 10 years.

**Site disturbance** Low-impact logging disturbance and mechanical site preparation may have increased vegetation by exposing buried seed and encouraging suckering through mechanical root damage. In the SBS zone, for example, Hamilton and Yearsley (1988) found that mechanical site preparation increased black huckleberry, thimbleberry, red osier dogwood, aspen, birch, and cottonwood. On the other hand, moderate to high impact mechanical site preparation can allow good initial vegetation control (Mackinnon and McMinn 1988). However, Utzig and Walmsley (1988) warn that heavy machinery must be used with caution if loss of surface organic horizons and compaction are to be avoided.

Low burning intensity can also stimulate shrub regrowth. Haeussler and Coates (1986) and Hamilton and Yearsley (1988) found that moderate to high impact broadcast burning helps control shrubs. Field observations indicated that broadcast burning often greatly increased the abundance of fireweed and thimbleberry compared to that on unburned sites, but that vigorous competition did not occur until up to 5 years after burning.

**Scheduling** Correct scheduling of brush control treatments is critical to achieving reforestation success. Early treatments are required to control vegetation that threatens survival. Brush treatments undertaken more than a few years after planting are too late to prevent most mortality. In the ICHg2 and g3 brush control was conducted on only 2 openings in the first 5 years while 62% of brush control conducted occurred 11 years or more after logging.

On sites prone to brush invasion, prompt planting can greatly improve reforestation success. In the ICHg2 and g3 57% of all successful plantations were planted within the first 2 years after logging.

**Treatment Factors**

**Harvesting** Regeneration success is influenced by harvesting timing and the intensity of cut (Cleary *et al.* 1978). Foresters working in the ICHg1 found that broadcast burning and brush development were the two treatment factors most affected by the length of time taken to harvest an area. Where logging contractors took several seasons to log an area, broadcast burning had limited success. Where delays have already occurred and an area has "greened up," killing brush with a broadcast herbicide application before burning has proven successful (J. Lloyd-Smith, pers. comm., 1988).

As well logging timing can affect brush development. Where an opening is logged over a period of 2 or 3 years, brush growth can be extensive, making planting more difficult and reducing seedling survival.

Season of logging also influences regeneration success. In many years in the ICHg, soils do not freeze before snowfall and, consequently, winter logging can result in soil compaction and rutting.

Site disturbance through ground skidding can also cause compaction and erosion, reducing plantable spots and survival rates. Interest was expressed in increased utilization of cable systems for such conditions. To date, very little cable logging has occurred in the ICHg.

**Site Preparation** Most site preparation in the ICHg1 and 1a has occurred 3 - 5 years after logging. Burning delays are common because the small fall burning window in this variant reduces the chance for a successful broadcast burn, especially where a high impact burn is desired. Summer burning is an alternative, and with adequate fireguarding, it can be less costly and more effective than fall burning in achieving medium to high impact broadcast burns (S. Schmidt, pers. comm., 1988). In general site preparation delays have less effect on reforestation success than logging or planting delays.

Site treatments were considered to be moderately important in causing NSR. The desired level of site preparation impact represents a trade-off between the short-term benefits of improved plantability and vegetation competition, and the possible long-term damage to the site through reduced productivity. On zonal sites, forest floor reduction should be minimized to retain site nutrients, but on richer sites this is not critical [8]. In the past, hot burns have occurred on shallow soils in the Kinskuch area, resulting in reduced site productivity (D. Tuomi, pers. comm., 1988).

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8 Macadam, A. 1988. B.C. Ministry of Forests memorandum re: Field inspection of cutblocks in the ICHg4 variant, Kalum Forest District, for assessment of broadcast burning impacts. Unpubl.

Field assessment showed that both high and low impacts had resulted from mechanical site preparation. Crawler tractor treatments had excessively scalped surface mineral horizons, and incomplete treatments had stimulated brush development. In a reforestation problem analysis conducted in the ICH in the Clearwater and Horsefly Districts, Butt and Bancroft concluded that the quality of site preparation treatments was more important than treatment type[9]. They also concluded that high impact mechanical treatments were most likely to lead to site degradation.

**Reforestation** As stated earlier, planting success is highest when planting occurs within 2 years of logging. Planting season is also an important facet of planting timing. Foresters in the ICHg1 used to concentrate all their planting efforts into the spring. However, results from a 14 year trial in the SBSe showed that the planting season for both pine and spruce could be extended to the entire frost-free period (LePage and Pollack 1986). One advantage to extending the planting season into the summer is that it gives more flexibility and opportunity to reforest. However, in the ICHg late summer planting can be restricted by early frosts (D. Davies, pers. comm., 1988), and the planting window for summer spruce stock can be restricted because it is slow to harden-off and may not be ready for planting until August.

Many foresters believe that poor stock quality was a major factor in contributing to NSR (rated 7th out of 30 in the questionnaire). Extended cold storage is believed to reduce stock quality and, therefore, stock survival (DeYoe 1985).

Stock type was rated as the 10th most important factor contributing to NSR. In one assessment, lodgepole pine bareroot stock had lower survival rates (78-85%) than did pine plugs (90%) (R. Goertzen, pers. comm., 1988).

A final concern with planting stock is the limited availability of subalpine fir. Many foresters feel that it suits areas subject to heavy snow loading, sites prone to heavy brush, and areas with high levels of tomentosus root rot (*Innotus tomentosus*). Because of subalpine fir's low germination rates and slow seedling growth rates in the nursery, other less suitable species have been planted instead. The cultural problems with subalpine fir are currently being investigated (Leadem 1988).

**Natural Regeneration** Questionnaire respondents rated natural regeneration as being unimportant in contributing to NSR, yet both the history record system and field sampling showed that historical reliance on natural regeneration, in unsuitable conditions, resulted in large areas of NSR. Historically, lack of funds, seed, and stock contributed to the reliance on natural regeneration. Although currently some foresters rely on natural regeneration to stock dry sites, most avoid it as a reforestation method because it tends to be composed largely of western hemlock (Figure 5). Ministry of Forests stocking standards introduced after 1981 allow hemlock as a minor component only, and then only on some sites.

### Management factors

Questionnaire respondents felt that management decisions sometimes contribute to regeneration failures. Lack of experience results in poor prescriptions, and incorrect site preparation or species selection. Some foresters felt that because treatments were sometimes conducted without backup information on objectives, constraints, or even methods, new foresters in the area were unable to learn from past practices.

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9 Butt and Bancroft, 1988.

Lack of funding for forest renewal was also felt to contribute to regeneration failure. Several problems related to it were identified:

- inadequate supervision of planting;
- areas that should have been planted being left instead for natural regeneration;
- inadequate survey information and blanket prescriptions; and
- lack of brush control.

Many foresters said that funding for silviculture today is substantially better than before. Funding through FRDA and increased stumpage rate in the SBEP are particularly important in this regard.

Resource use conflicts were not considered to be important in creating reforestation problems, although some foresters expressed concern about the negative public attitudes toward herbicide spraying. Two foresters called for a fish and wildlife inventory, and establishment of fish and wildlife management requirements. Such concerns primarily affect brushing and weeding programs.

### 3.3.2 ICHg2 and ICHg3: analysis of factors

Much of the analysis for the ICHg1 and 1a is relevant to the ICHg2 and 3. Discussion in this section is limited to those observations specific to the ICHg2 and 3.

#### Site factors

Several site factors have influenced regeneration success in the ICHg2 and 3, including: duff depth, cold soils, soil moisture levels, snow press, cold air ponding, and pests. Questionnaire respondents noted that deep humus horizons (~20 cm) are a problem, particularly in the Suskwa River Valley. Neither broadcast burning nor V-plowing reportedly reduced duff sufficiently, and planter screefing on these sites produced large holes that subsequently filled in, burying the seedling. Although broadcast burning can reduce duff depth by up to 80% (R. Trowbridge, pers. comm., 1988), it is not normally recommended for this because of the impact on nutrient capital.

Results from field sampling on two sites in the ICHg3 suggest that poor survival and growth are related to cold soils. Humus on these imperfect to poorly drained sites insulates the mineral soil, preventing soil warming and early root growth in the spring (Spittlehouse 1985). Preparation of a raised planting site by mounding or plowing can significantly increase soil temperature and improve drainage (Spittlehouse 1985). However, as was stated before it is too early for conclusive results from operational mounding trials in the ICHg.

Problems with excessive moisture levels are similar to those in the ICHg1. Regeneration failures are common on areas with high water tables. Some foresters also pointed out that roads and landings can intercept seepage water, causing additional drainage problems.

Although moisture stress during the summer is more frequent in the ICHg3 than in the ICHg1 (Haeussler *et al.* 1985), thus reducing the summer planting season, an early snowmelt in the ICHg3 allows for an extended spring planting season. Drought was not noted to be a significant factor in regeneration failures in the ICHg3.

Other site factors causing reforestation problems similar to those in the ICHg1 and 1a are snow press and cold air ponding. Both were noted during field sampling. According to Haeussler *et al.* 1985, cold air ponding is common in the ICHg3.

With the exception of *Hylobius warrenii*, pest problems were less evident in the ICHg2 and 3 than in the ICHg1 and 1a. *Hylobius warrenii* appears to be a common problem in the

ICHg2 and 3[10], and has been observed in a number of young plantations (3 - 6 years old) where it caused seedling mortality (T. Ebata, pers. comm., 1988). This has raised much concern, as *H. warrenii* is normally a problem in older stands (10 - 20 years). The degree to which *Hylobius* has caused NSR has not been well documented.

**Vegetation factors**

Competing vegetation was identified as a major factor in causing reforestation failures. In the ICHg3, seral stands of aspen and birch are more common than in the ICHg1 because of climate, natural fires, and widespread human disturbance. Dense shrub and herb layers characterize these stands and make rehabilitation very difficult.

Brush occurrence following harvest in conifer-dominated communities in both the ICHg2 and 3 is closely related to hygrotope. Competition on submesic sites comes from fireweed, rose (*Rosa acicularis*), and aspen, but is normally of little concern. On mesic sites, fireweed, rose, thimbleberry, aspen (*Populus tremuloides*), and birch are the main competitors. Hazelnut (*Corylus cornuta*) can also be an aggressive competitor for light and soil moisture (Haeussler *et al.* 1985). The proliferation of seed banking species and the proximity of deciduous seed sources mean that seed-in of brush is usually rapid, abundant, and an important concern.

Subhygric and hygric sites are rated by Haeussler *et al.* (1985) as the highest brush hazard areas in the ICHg. Competing vegetation is often present in the mature stand and develops rapidly when the canopy is opened up. Species such as fireweed, raspberry, thimbleberry, hazelnut, red osier dogwood, aspen, and birch are common. Field sampling also showed grasses and sedges to be common on hygric sites.

Although the cause of some NSR areas has been attributed to brush competition, several brush control treatments have been tried in the ICHg with success, including manual treatments, backpack and aerial spraying with glyphosate, hack and squirt using glyphosate, and ground application of hexazinone with spears. Comments from foresters during the study indicate that the key to success is to act at the earliest stages of brush development.

**Treatment factors**

Much of the comment on treatment factors relating to the ICHg1 and 1a is also applicable to the ICHg2 and 3. However, several points unique to the ICHg2 and g3 should also be noted. Brush invasion following mechanical site preparation is especially rapid in these variants (G. Burns, pers. comm., 1988). Because of this, planting activities must be conducted as soon as possible following site preparation.

Another factor affecting successful reforestation is the traditional scheduled planting in the spring of the ICHg3, because of concerns with summer drought. Consequently, the planting program is less flexible, stock quality may be poorer, and planters are less experienced on average, than later in the year. Some foresters suggested that more summer planting be conducted on seepage sites or sites with a high water table - areas that are not prone to summer moisture deficits.

### 3.3.3 ICHg4 and ICHg5: analysis of factors

Logging and silviculture activities have been minimal in the ICHg4 and 5, and so less is known about factors affecting reforestation failures. However, results from field sampling and the questionnaire showed similar influences to that experienced in the ICHg1. Much of the comment in

10 Laing & McCulloch Forest Management Services. 1987. Pest survey in young stands, Prince Rupert Forest Region. B.C. Ministry of Forests, Protection Branch, Smithers. Unpubl. report.

section 3.3.1 is therefore applicable in the ICHg4 and 5 as well. The following discussion pertains only to new factors not yet addressed or factors whose impact was different in the ICHg4 and 5 than in the ICHg1 and 1a.

**Site factors**

Site factors with the greatest effect on regeneration success in the ICHg4 and 5 were humus depth, snow loading, and cold air ponding. Shallow humus over coarse textured substrata in parts of the Bell-Irving river drainage (ICHg 4) have caused some reforestation problems (B. Wilson, pers. comm., 1988). Humus depth was also a concern in the ICHg5 where it was generally shallow.

The site factor that most concerned foresters in the ICHg4 was snow press. Heavy, wet snowpacks of 3-6 m are common (Haeussler *et al.* 1985). Snow loading, in conjunction with matted herbaceous material on seedlings, flattens or bends young trees. Older trees suffer broken and forked tops.

The problem is most apparent with spruce stock and on moist areas that have been broadcast burned. Burning stimulates growth of fireweed and other herbs which die back annually and, when dense enough, form a vegetation mat over seedlings. The mat creates a much larger surface area for snow loading than that to which the seedling would normally be exposed.

The various spruce hybrids in the ICHg4 are believed to respond differently to snow press. Research is under way to determine the different hybrid types, and detailed seed collection boundaries will have to be delineated for the ICHg4 (J. Konishi, pers. comm., 1989).

The third most important site factor contributing to regeneration failure in the ICHg4 is cold air ponding. Mortality from frost damage is particularly high along the Bell-Irving river drainage, where western hemlock is absent from valley bottoms because of cold air ponding.

A final note on site factors in the ICHg4 is that *Pissodes strobi* was observed during field sampling on an older spruce plantation in the area. Foresters should be prepared for higher levels of this pest in future if spruce continues to be the only species planted in this variant.

**Vegetation factors**

Major competing species include fireweed, thimbleberry, grass, rose, red osier dogwood, willow (*Salix* spp.), and aspen. Red osier dogwood and grasses are generally restricted to wetter sites, while rose is a problem on mesic and drier sites.

To date, no brushing has occurred in these variants, although field sampling indicates that brush development is becoming a serious problem in young plantations. As new forest licences are obtained in the ICHg4, vegetation control will become a major concern. Current logging is scheduled along the valley bottoms and lower slopes, which are dominated by subhygric sites having moderate to severe brush hazards (Haeussler *et al.* 1985). No timber sales are planned in the ICHg5 for the next few years, but rehabilitation on parts of the Iskut burn may necessitate vegetation control (J. Thibeau, pers. comm., 1988).

**Silviculture factors**

Treatment factors affecting regeneration success in the ICHg4 and 5 centre on planting, since few other activities have been conducted in these variants. Prompt site preparation and planting have typified recent reforestation efforts.

There are two main planting constraints that could affect regeneration success. First, because snow melt is not complete until June, seedlings must be kept in cold storage for up to 8 months before planting. This could affect stock quality. Second, because hybrid Sitka spruce

stock does not "harden-off" until August, summer planting cannot take place in the ICHg4 until then. This increases the risk of failure since early frosts are common in August (D. Davies, pers. comm., 1988), and planting dates outside the frost-free period can reduce survival rates (LePage and Pollack 1986).

In these variants, initial results with interior spruce PSB 313 plug stock has been poor. Seedlings that survive the 1st year and develop a larger caliper do much better (B. Wilson, pers. comm., 1988).

Past experience shows that natural regeneration in the ICHg4 and 5 on logged sites yields poor results (only 12% of all area left for natural regrowth is now SR). According to Parnell (pers. comm., 1988), it takes at least 10 years on brush-free sites in the ICHg5 to obtain 66% of required minimum stocking levels. A recent survey in a portion of the Iskut burn showed that approximately 30% of the area successfully regenerated after 30 years. With such poor results, it seems clear that reforestation through natural regeneration is a poor option in these variants.

**Management factors**

More than 8000 ha of backlog NSR exist in the ICHg4 and 5, most of it resulting from wildfire (Table 4). One reason such a large area continues to be of NSR is the low priority placed on funding forestry activities on relatively remote wildfires.

Another factor contributing to regeneration failure in these two variants is lack of silviculture management experience. In the past, low budgets have resulted in little silviculture activity and few foresters employed in the area. This has resulted, in turn, in limited long-term experience in the area.

A third factor that could contribute to reforestation problems in the future is public pressure against herbicide use. If there is not an agressive public involvement campaign, conflicts with local residents and high values placed on fish and wildlife will restrict herbicide use. Although this has not been a big factor in the past, it will become more important as brush-prone sites being logged now reach the age where brush control is necessary.

# 4 CONCLUSIONS AND RECOMMENDATIONS

## 4.1 Forest Management Implications From History Record Analysis

The history record analysis revealed a number of important trends:

- Silvicultural treatment effort has been extremely low in the ICHg4 and 5 (3% of denuded area treated), moderately low in the ICHg2 and 3 (65% treated), and high in the ICHg1 and 1a (90% treated). However, in absolute terms, total area treated was much higher in the ICHg2 and 3 (8022 ha) than in the other variants (3513 ha for the ICHg1 and 1a, and 125 ha for the ICHg4 and 5).
- Site preparation before planting in the ICHg1, 1a, 2, and 3 appears to have had little influence on plantation survival, compared to planting without site preparation (86% of area which had been site prepared and planted is SR, compared to 85% of area which had been planted **without** site preparation being SR).
- Regeneration success in an area that is planted is far superior to regeneration success in an area that is left for natural regrowth (83% of area planted is SR compared to only 32% of area left for natural regrowth).
- Where natural regeneration has been successful, western hemlock predominated (hemlock was the leading species on 59% of naturally regenerated SR areas).

This information has two main implications for forest managers:

1. Burning and mechanical site preparation appears to have less influence on plantation survival than is commonly expected. However, this does not imply that site preparation should not be conducted. Planting and brushing costs are often greatly reduced by site preparation treatments. Other long-term benefits include disease control, improved seedling performance, and improved distribution of stocking.

2. Natural regeneration currently has limited application as a reforestation system in the ICHg. Conditions under which the preferred method of reforestation is natural regeneration are limited. Furthermore, total silvicultural costs for natural regeneration, including spacing, may not be lower than the cost of artificial regeneration.

## 4.2 Recommendations for Managing the 10 Main Factors Contributing to Reforestation Failure in the ICHg

The 10 main factors contributing to reforestation failures in the ICHg are discussed below, in descending order of importance, with management recommendations.

### 4.2.1 Treatment scheduling

Incorrect treatment scheduling was identified as the most important factor contributing to reforestation failures. This was especially true on brush-prone sites where treatment delays for logging, planting, and burning were critical.

Treatment schedules will be established with the Pre-harvest Silviculture Prescription, and should provide sufficient lead time for managers to plan and coordinate activities. Treatment priorities must be identified at this stage and the costs of treatment deferral considered. Delaying silviculture treatments is costly, it can contribute to the creation of NSR, and subsequent silviculture treatments are often more expensive and have a higher risk of failure.

### 4.2.2 Vegetation competition

Vegetation competition is frequently a problem on mesic and moister sites. The main competing species are grasses (*Calamagrostis* spp.), *Epilobium angustifolium*, *Rubus parviflorus*, *Cornus sericea*, *Populus tremuloides*, and *Betula papyrifera*. Distribution and abundance of these species is tied to soil moisture levels and disturbance levels. Brush development is generally rapid, particularly in the ICHg2 and 3, because of the diversity of species present and the abundance of seral stands containing hardwoods. A number of conclusions can be drawn:

1. Natural regeneration and planting delays must be avoided on brush-prone sites.

2. Regeneration delay guidelines (B.C. Ministry of Forests, PRFR, 1988) on mesic sites are too tolerant. Every effort should be taken to ensure reforestation occurs within 3 years.

3. Obtaining a level at which site preparation is most effective requires trading off between improved plantability and vegetation competition, and a possible reduction in site productivity. Excessively high and low impact levels should be avoided. To achieve an appropriate impact, skilled operators and close supervision are required.

4. Broadcast burning or other treatments that stimulate herbaceous development should be avoided in areas subject to heavy snow loading. Planting subalpine fir, planting larger caliper stock, or using early brush treatments, may be other alternatives.

5. Management to promote hardwood species should be considered in areas where the cost of brush control or stand conversion is excessive. Overseas markets for aspen, birch, and cottonwood already exist (R. Harris, pers. comm. 1988). Pure or mixed hardwood stands should be considered. Further research will be required to ascertain acceptable species mixes and stocking levels for mixed stands.

6. Brush-prone areas must be identified at the pre-harvest stage so that measures can be taken during logging, site preparation, and planting to reduce the risk of brush development, and so that early brush treatments can be scheduled.

7. Successful treatment of red osier dogwood in the past has been very difficult. New studies have shown that operational control of red osier dogwood should be carried out in August with glyphosate, when the species is susceptible (F. Newhouse, pers. comm., 1989). Moderate control of young red osier dogwood can occur, while it is maintained as a browse species.

#### 4.2.3 Natural regeneration

In the past, reliance on natural regeneration on inappropriate sites resulted in a failure rate of 68%. Natural regeneration as a reforestation method should be restricted to sites where western hemlock regeneration is acceptable. Following completion of a study by Farnden [11], in which preliminary results favour accepting western hemlock on a wider variety of sites, foresters may once again regard natural regeneration as an alternative option or rely on it more heavily for natural ingress. General guidelines to site selection for natural reforestation are as follows:

1. On sites where seed-in is expected to be poor, greater than 2000 well spaced, acceptable seedlings, less than one meter in height must be present before logging. If cable systems are used some regeneration can be taller than 1 m and if logging occurs on a snow pack lower initial stocking will be sufficient.

2. Where seed-in is expected to be the main source of regeneration, the maximum distance to the seed source (assuming hemlock, cedar, or spruce predominance in the canopy) should be approximately 200 m. Good seed crops must be frequent.

3. Although hemlock germinates and survives on a wide variety of seedbeds, some site disturbance will improve seed-in. Skidder logging in the summer is a preferred way of achieving this.

4. When naturally regenerating pine, cone serotiny should be verified. Where cones are serotinous, pine must represent approximately 80% of the canopy within the opening for natural regeneration to be successful. Falling and yarding practices which result in good mineral soil exposure and which leave cones on the ground will improve results (ie: top and limb in the bush and yard with skidders in the summer). Drag scarification may be required when ground cone distribution and/or mineral soil exposure is insufficient.

5. Natural regeneration should not be attempted on brush prone sites. Avoid wet, rich ecosystem associations.

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11 Farnden (Industrial Forestry Services). 1988. Assessment of performance of second growth *Tsuga heterophylla* in the ICH zone of the Prince Rupert Forest Region. Preliminary results. B.C. Min. of For., Prince Rupert Forest Region. Unpubl. report.

#### 4.2.4 Record keeping and experience of personnel

Poor prescriptions, lack of experienced equipment operators, and lack of accurate up-to-date records have also contributed to reforestation problems. Silviculture prescriptions determine how the silviculture budget is spent. A large amount of money can be spent on poor prescriptions that may be incorrect or less than optimal. The potential cost of poor prescriptions should be an incentive to management to spend more on staff training and to hire more-experienced contractors. Field-checking a portion of completed work to assess validity of summaries and prescriptions is important. Several survey courses have been developed by the Ministry of Forests to improve information accuracy and prescriptions. These courses should be an important part of staff training.

Local equipment operators should be trained and used so that local expertise remains in the area. Contracts could be awarded on a point system, which gives an advantage to those with local or more relevant experience.

Updating silviculture records is an important phase of project completion, especially where information can be lost during staff turnover. Budget allocation, treatment scheduling, and analysis of treatment success are important aspects of forest management, and all are based on silviculture records.

Silviculture records need to be easily accessible to field staff to facilitate updating. It is important that post-treatment assessments and the original treatment objectives be included in the history records to improve analysis of treatment success.

#### 4.2.5 Treatment impacts

High treatment impacts have contributed to reforestation failures. Excessive site disturbance from ground skidding on steep slopes, wet sites and thin soils, and from high impact broadcast burning on thin humus sites has contributed to NSR. Acceptable treatment impact should be identified during layout and pre-harvest silviculture prescriptions. Realistic alternative logging and site preparation methods should be specified if preferred treatments cannot be conducted. During layout, small units that will be detrimentally impacted by the main treatment, and cannot be isolated from it, should be excluded from the opening.

On wet sites, using high flotation skidders and winching more frequently, and restricting logging activities to dry periods, would help reduce compaction and rutting. On thin soils, smaller machinery could be used. Site preparation objectives should be conveyed to operators. In general, site treatments should better reflect the heterogeneity of the site. This may mean reducing cutblock size to logical silviculture units rather than to logical timber marketing units.

#### 4.2.6 Moisture levels

Moisture contributes to reforestation failures on sites which, primarily because of physiographic or edaphic factors, experienced summer moisture deficits, and on sites with a high water table. Moisture problems should be identified through on-site assessment before logging so that harvesting methods, logging season, logging equipment, and number of machine passes can be changed to reduce site impacts. In some cases, highly sensitive areas can be excluded from the block. On moisture-deficient sites, a high priority should be placed on planting immediately after snow melt, preferably using small plug stock or mechanical site preparation techniques that improve moisture retention (such as a patch scarifier). On sites where excessive moisture is a problem, mounding or plowing could be beneficial. However, further research and small operational trials are advisable before any large-scale operations are conducted.

### 4.2.7 Snow press

Snow press is a major problem in the ICHg4 where snow loading, in conjunction with herbaceous matting, causes bending and breakage. In other variants, snow damage is not as widespread but is important locally. The most susceptible areas appear to be moister sites and sites that have been broadcast burned. Potential treatments include: using larger caliper stock; encouraging regeneration of more resistant species, such as different spruce hybrids or subalpine fir; and avoiding site preparation treatments, such as broadcast burning, that promote the development of herbaceous vegetation. Early brush control may also help alleviate the problem. Snow press in the newer plantations will require monitoring to determine the best combination of treatments.

### 4.2.8 Stock type and quality

Poor stock quality, resulting at least partly, from extended cold storage, delay in bud set (hybrid Sitka spruce summer stock), and non-acclimatized spruce stock have contributed to reforestation failures. The PSB 313 plug has been particularly poor on brushy sites and sites subject to heavy snow loading. Site characteristics must be considered during prescription development at the pre-harvest and planting prescription stages. Appropriate stock types must be matched to site characteristics. Sturdier stock should be prescribed for brushy and heavy snow sites, where the superior performance of larger stock should outweigh the cost (McMinn 1985b). Further experimentation will also be necessary with subalpine fir stock to improve germination and seedling performance. Initial results seem to show that if the problem with late bud set in hybrid Sitka spruce stock can be overcome, more summer planting in the ICHg4 can be conducted.

### 4.2.9 Cold air ponding

Frost damage, poor seedling performance, and kill was frequently noted on spruce regeneration in depressions and broken terrain. Failure to recognize the potential for cold air ponding and to prescribe alternative courses of action has been typical in the past. A field guide for recognizing and dealing with these sites is being developed (FRDA project 3.65) to address this problem. Acclimatized stock must be used on cold air ponding sites to avoid undergoing initial heavy frost damage. Mechanical site preparation, mounding, or plowing may be used to improve soil warming. Potential problem sites should be identified in the Pre-harvest Silviculture Prescription. On extreme sites, frost-resistant species such as subalpine fir or mountain hemlock may be appropriate. In extreme cases, it may be worthwhile to modify block boundaries to exclude these areas.

### 4.2.10 Budget

Historically, lack of funding for planting stock and other silviculture treatments has resulted in high levels of NSR on areas denuded through logging and wildfire. Recently, increased funding through the SBEP and FRDA has resulted in a notable improvement. The challenge to forestry is to ensure that the funds are spent effectively. More funding for research will also be required to ensure that previous investments are not lost (for example, through pest epidemics), and to solve the many problems still facing foresters. An often overlooked task of the forester is to make sure that accountants and other management personnel are aware of the benefits of budgeting for prompt reforestation and sustained growth.

## 4.3 Research Requirements

As part of the questionnaire process, foresters were asked to determine which factors contributing to regeneration failure most needed to be addressed through further research or training. The 10 factors with the highest priority are shown in Table 6.

TABLE 6. Priority for addressing factors contributing to regeneration failure

| Factor | Rank |
|---|---|
| Treatment Scheduling | 1 |
| Shrub Competition | 2 |
| Hardwood Competition | 3 |
| Training of Personnel | 4 |
| Treatment Impact | 5 |
| Stock Quality | 6 |
| Planting Scheduling | 7 |
| Stock Type | 8 |
| Snow Press | 9 |
| Herbs | 10 |

Many of the factors could be adequately addressed by summarizing existing information (for example, in an Operational Summary) or through existing training courses (e.g.,SIBC, PHSP Training course, Reforestation Recommendations Course, Vegetation Management Course). There are also a number of current research projects that address related topics:

- cold air ponding - FRDA 3.65
- germination of sub-alpine fir seed for nursery production - FRDA 2.41
- cultural regimes for *Abies lasiocarpa* - FRDA 1.43
- burning impact in the ICHg1 - EP 953.01
- acceptability of western hemlock in the ICHg - Research, (PRFR)

As well, it is recommended that a number of specific topics be addressed through further research:

1. Determination of the correlation among pre-harvest vegetation, silviculture treatments, and post-treatment vegetation

   Vegetation competition was consistently identified as one of the key factors contributing to regeneration failure. It was also rated as a high priority for further research. The ability to predict vegetation response to logging and site preparation is an essential component of effective prescription development. This is especially true, given current cutting permit guidelines which require that a brush control plan be stated before harvest, in the Pre-harvest Silviculture Prescription document.

2. Management of high water table sites

   Invariably, sites with high water tables are problem sites. Although such sites are normally only small units within an opening, they occur frequently. Foresters are unable to prescribe effective treatments in these areas because there is a lack of information on:

   - how water table levels change following harvest;
   - how logging methods and season affect drainage and soil characteristics;
   - how mounding, ripping, and drainage affect seedling survival and development and brush development.

3. The effects of snow press on seedling survival and growth

   Snow press contributed significantly to regeneration failures in the ICHg4 and was also apparent in other variants. However, no information is available on mortality levels or stem deformation and recovery. Acceptable time frames when snow press does not cause significant damage needs to be defined. This information should be the basis for decisions made on choice of species, stock type, and site preparation treatment.

4. Trends in population levels of *Pissodes strobi* in the ICHg

   Although the incidence of *Pissodes strobi* throughout the ICHg is low, it was noted that levels seem to be building along drainages adjacent to the CWHf where populations have been high. W. Martin (pers. comm., 1988) and D. Tuomi (pers. comm., 1988) observed that populations seem to be spreading inland, and they fear that if large, contiguous areas of spruce continue to be planted, epidemic levels could develop. Results in the Kitimat Valley of heavy attacks have been devastating and many plantations have been destroyed. Analysis of population trends in the ICHg is an important factor in determining species to be regenerated in the future.

5. Guidelines for management of *Hylobius warrenii*

   Warren's root collar weevil has recently been identified as a major problem in some plantations, particularly in the ICHg3. Information on incidence levels, effect on seedling growth and survival, and treatment options is needed if foresters are to manage effectively against this pest.

6. Hardwood or mixed management in the ICHg2 and 3

   Hardwood stand management should be considered on difficult-to-manage sites. Overseas markets for hardwood species already exist. Research is required to determine acceptable stocking levels for hardwoods and appropriate species for mixed stands.

7. Guidelines for active management of natural regeneration

   Historically, 32% of the area denuded through logging in the ICHg was left for natural regeneration. The failure rate on these sites was high (68%). If hemlock is accepted as a crop species in the future, foresters will again rely on this method of reforestation. It is essential, therefore, that clear guidelines be developed on appropriate harvesting practices, quality and quantity of advance regeneration, distances to the seed source, appropriate site types, and other factors affecting its success.

8. Grass control on wet sites

   Current brush control practices cause vegetation to shift on wet sites from shrubs to predominantly grass. Grass roots compete with seedlings. The plant also contributes to snow press and prevents soil warming by developing a thick mulch (Haeussler and Coates 1986). Brush control treatments must be developed that do not result in one problem species being replaced by another.

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## APPENDIX 1

## QUESTIONNAIRE

LAING & McCULLOCH FOREST MANAGEMENT SERVICES
BOX 2519 • SMITHERS, B.C. • V0J 2N0 • (604) 847-3267

July 18, 1988

Dear Forester:

LAING & McCULLOCH Forest Management Services is under contract to the Ministry of Forests to conduct a problem analysis of reforestation problems in the ICHg in the Prince Rupert Forest Region. The objectives are to determine the nature and extent of reforestation problems in the ICHg, identify proven operational solutions and summarize research needs where solutions do not exist.

The analysis has several components including a synthesis of local knowledge of operational results through a questionnaire and follow-up telephone interview with people involved in reforestation in the ICHg. We felt your experience in the area would provide invaluable information and hoped you would take the time to respond to the attached questionnaire. This information along with results collected from history records, on-site inspections and a literature review will be published in a report. A workshop and demonstration sites will also be provided to furthur help disseminate findings. We hope that by providing this information, forest management in the ICHg will improve and we would appreciate your contribution.

If you have any questions, contact Leisbet Croockewit or Larry McCulloch at 847-3267. We would appreciate a response by August 2nd, 1988. Thank you for your attention in this matter.

Thank you

Leisbet Croockewit, R.P.F.

Larry McCulloch, R.P.F.

LAING & MCCULLOCH
FOREST MANAGEMENT SERVICES

REFORESTATION PROBLEM ANALYSIS WITH OPERATIONAL SOLUTIONS FOR THE ICHg SUBZONE,
PRINCE RUPERT FOREST REGION

QUESTIONNAIRE

NAME: _____ DISTRICT OR COMPANY: _____ DATE: _____

# OF YEARS WORKING IN THE ICHg: _____ ICHg VARIANTS YOU WORK IN: _____

FACTORS WHICH CONTRIBUTE TO REFORESTATION PROBLEMS:

Fill in the columns below to show under which conditions each factor contributes to reforestation problems. Reforestation problems means areas that are considered NSR or areas showing poor performance; where, poor performance means marginal stocking, reduced height growth and/or pest damage.

| FACTORS | VARIANTS | SITE SERIES | TYPE OF DISTURBANCE | SPECIES | RANKING #1 | PRIORITY TO TREAT #2 | COMMENTS: REASON & TYPE OF FAILURE | TESTED SOLUTIONS #3 |
|---|---|---|---|---|---|---|---|---|
| CHOICES | 1,1a,2,3,4,5 | dry/mesic/moist/all | all;N/A | Sx,Pl,Hw,Cw,Ba,Bl | 1 - 30 | H,M,L,N | - | type/successful/unsuccessful |
| eg. Logging Scheduling | 1,1a,2 | mesic/moist | all | N/A | 15 | L/N | compaction of fine soils reducing the rooting zone - poor performance | winter logging/ somewhat successful |
| MANAGEMENT FACTORS | | | | | | | | |
| Budget | | | | | | | | |
| Personnel | | | | | | | | |
| Product Objectives | | | | | | | | |
| Resource Use Conflicts | | | | | | | | |
| LOGGING | | | | | | | | |
| Scheduling | | | | | | | | |
| Method | | | | | | | | |

NOTE:
#1 - ranking means importance in relation to the other factors, where #1 is most important.
#2 - priority for treatment of the problem.
#3 - treatments which have been used to attempt to resolve problems caused by these factors.

| FACTORS / CHOICES | VARIANTS | SITE SERIES | TYPE OF DISTURBANCE | SPECIES | RANKING #1 | PRIORITY TO TREAT #2 | COMMENTS: REASON & TYPE OF FAILURE | TESTED SOLUTIONS #3 |
|---|---|---|---|---|---|---|---|---|
| CHOICES | 1, 1a, 2, 3, 4, 5 | dry/mesic/moist/ all | all;N/A | Sx, Pl, Hw, Cw, Ba, Bl | #1 - 30 | H, M, L, N | - | type/successful/unsuccessful |
| TREATMENTS | | | | | | | | |
| Timing | | | | | | | | |
| Impact | | | | | | | | |
| PHYSIOGRAPHY | | | | | | | | |
| Slope | | | | | | | | |
| Aspect | | | | | | | | |
| Elevation | | | | | | | | |
| SOILS | | | | | | | | |
| Humus Depth | | | | | | | | |
| Soil Texture | | | | | | | | |
| Soil Depth | | | | | | | | |
| Nutrient Status | | | | | | | | |
| WATER/SNOW | | | | | | | | |
| Moisture Level | | | | | | | | |
| Snow Press | | | | | | | | |
| Frost Pockets | | | | | | | | |
| VEGETATION (species?) | | | | | | | | |
| Hardwoods | | | | | | | | |
| Other Conifers | | | | | | | | |
| Shrubs | | | | | | | | |
| Herbs | | | | | | | | |

NOTE:
#1 - ranking means importance in relation to the other factors, where #1 is most important.
#2 - priority for treatment of the problem.
#3 - treatments which have been used to attempt to resolve problems caused by these factors.

| FACTORS | VARIANTS | SITE SERIES | TYPE OF DISTURBANCE | SPECIES | RANKING #1 | PRIORITY TO TREAT #2 | COMMENTS: REASON & TYPE OF FAILURE | TESTED SOLUTIONS #3 |
|---|---|---|---|---|---|---|---|---|
| CHOICES | 1, 1a, 2, 3, 4, 5 | dry/mesic/moist/all | all;M/A | Sx, Pl, Hw, Cw, Ba, Bl | 01 - 30 | H, M, L, N | - | type/successful/unsuccessful |
| PESTS (species?) | | | | | | | | |
| Animal | | | | | | | | |
| Insect | | | | | | | | |
| Disease | | | | | | | | |
| STOCK | | | | | | | | |
| Type | | | | | | | | |
| Quality | | | | | | | | |
| Scheduling | | | | | | | | |
| Naturals | | | | | | | | |
| ANY OTHER FACTORS? | | | | | | | | |

Can you list some sites where you have observed these factors causing regeneration failures that we could visit?

NOTE:
#1 - ranking means importance in relation to the other factors, where 01 is most important.
#2 - priority for treatment of the problem.
#3 - treatments which have been used to attempt to resolve problems caused by these factors.

## APPENDIX 2

## PERSONAL CONTACTS

Rod Arnold, Principal, RJA Forestry Services Ltd., Terrace.

George Burns, R.O. Silviculture, Kispiox Forest District, B.C. Ministry of Forests.

Leslie Bush, Surveys Co-ordinator, Prince Rupert Regional Office, B.C. Ministry of Forests.

Dave Coates, Research Silviculturist, Prince Rupert Forest Region, B.C. Ministry of Forests.

Doug Davies, Principal, KDM Forestry Services Ltd., Terrace.

Tim Ebata, Regional Entomologist, Prince Rupert Forest Region, B.C. Ministry of Forests.

Ron Goertzen, Silviculture Co-ordinator, Westar Timber Ltd., Hazelton.

Ross Harris, Woodlands Manager, Westar Timber Ltd., Hazelton.

Kim Haworth, District Silviculturalist, Kalum Forest District, B.C. Ministry of Forests.

Jenjii Konishi, Seed Production Manager, Silviculture Branch, B.C. Ministry of Forests.

Ann Macadam, Pedologist, Prince Rupert Forest Region, B.C. Ministry of Forests.

Wayne Martin, Regional Pathologist, Prince Rupert Forest Region, B.C. Ministry of Forests.

Fred Newhouse, Stand Tending Forester, Prince Rupert Forest Region, B.C. Ministry of Forests.

Grant Parnell, R.O. Silviculture, Cassiar Forest District, B.C. Ministry of Forests.

Fred Philpot, Principal, Philpot Forestry Ltd., Terrace.

Steve Schmidt, Regional Fire Prevention Coordinator, Prince Rupert Forest Region, B.C. Ministry of Forests.

John Thibeau, R.A. Silviculture, Cassiar Forest District, B.C. Ministry of Forests.

Rick Trowbridge, Regional Pedologist, Prince Rupert Forest Region, B.C. Ministry of Forests.

Dan Tuomi, Woodlands Manager, Skeena Cellulose Inc., Terrace.

Terry Walgren, Forestry Supervisor, Tay-M Logging, Terrace.

Bob Wilson, R.O. Silviculture, Kalum Forest District, B.C. Ministry of Forests.

## APPENDIX 3

## DISTRIBUTION OF QUESTIONNAIRE RESPONDENT EXPERIENCE

| | % Total Experience | | | | | |
|---|---|---|---|---|---|---|
| | ICHg1 & 1a | ICHg2 | ICHg3 | ICHg4 | ICHg5 | TOTAL |
| Ministry of Forests | 6.7 | 6.5 | 7.8 | 6.4 | 2.8 | 30.2 |
| Industry | 12.2 | 14.5 | 13.0 | 3.3 | – | 43.0 |
| Consulting | 7.0 | 7.0 | 7.0 | 3.8 | 2.0 | 26.8 |
| TOTAL | 25.9 | 28.0 | 27.8 | 13.5 | 4.8 | 100.0 |

## APPENDIX 4

## SAMPLE FIELD CARD

TENURE

| REGION | F.D. | LOCATION | T.S.A. | TSB | Est. ha affected: |
|---|---|---|---|---|---|
| LICENCE NO. | LICENSEE | C.P. | BLOCK | BCGS / OPENING NO. / SETTING NO. | PLOT NO. |
| PHOTO NO. | ASSESSED BY (Print) | | | DATE D M Y | |

SITE

| ELEVATION MIN. (m) | MAX (m) | ASPECT | PREDOM SLOPE % | SLOPE POSIT | TERRAIN | OTHER |
|---|---|---|---|---|---|---|
| | | | | | | |

ECOLOGICAL CLASSIFICATION
BGC Zone/Subzone/Var. _____
Eco. Assn. Type/Phase _____
Edaiopic Grid: Moist ____ Nutr. ____

HISTORY SYMBOL ○ | YEAR OF LAST DISTURBANCE

Photo #/Location:

SOIL DESC

SOIL HORIZONS

| Horizon | Depth | Texture | % C.F |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Rooting Depth ____ (cm) Restrictive Layer Depth ____ (cm)
Humus Form ____ Soil Order ____
Drainage ____
Landform ____
Other ____

BRUSH: N L M H

| BRUSH SPP | SPECIES %Cover | TALLY Ht(cm) |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

PEST MANAGEMENT

| Agent | Incid | Comments | SPP. Affected | # WS Affected |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

logging type/impact:

site prep type/impact:

reforestation yrs/spp/stock type:

amount of disturbance:

slash: %cover/ht

SURVEY PARAMETERS USED:

To assess well spaced trees or spots — TARGET / PLANTING

SURVIVAL %

STOCKING STANDARD /ha | MAXIMUM / PLOT | INTER-TREE SPACING IDEAL | MINIMUM

HEIGHT FOR REGENERATION TO BE VISIBLE cm

MINIMUM STOCKING STANDARD
WELL SPACED STEMS /ha

REPORT NO
SURVEY TYPE | OPENING NO | SURVEY NO

POINT OF COMMENCEMENT

WELL SPACED SPECIES

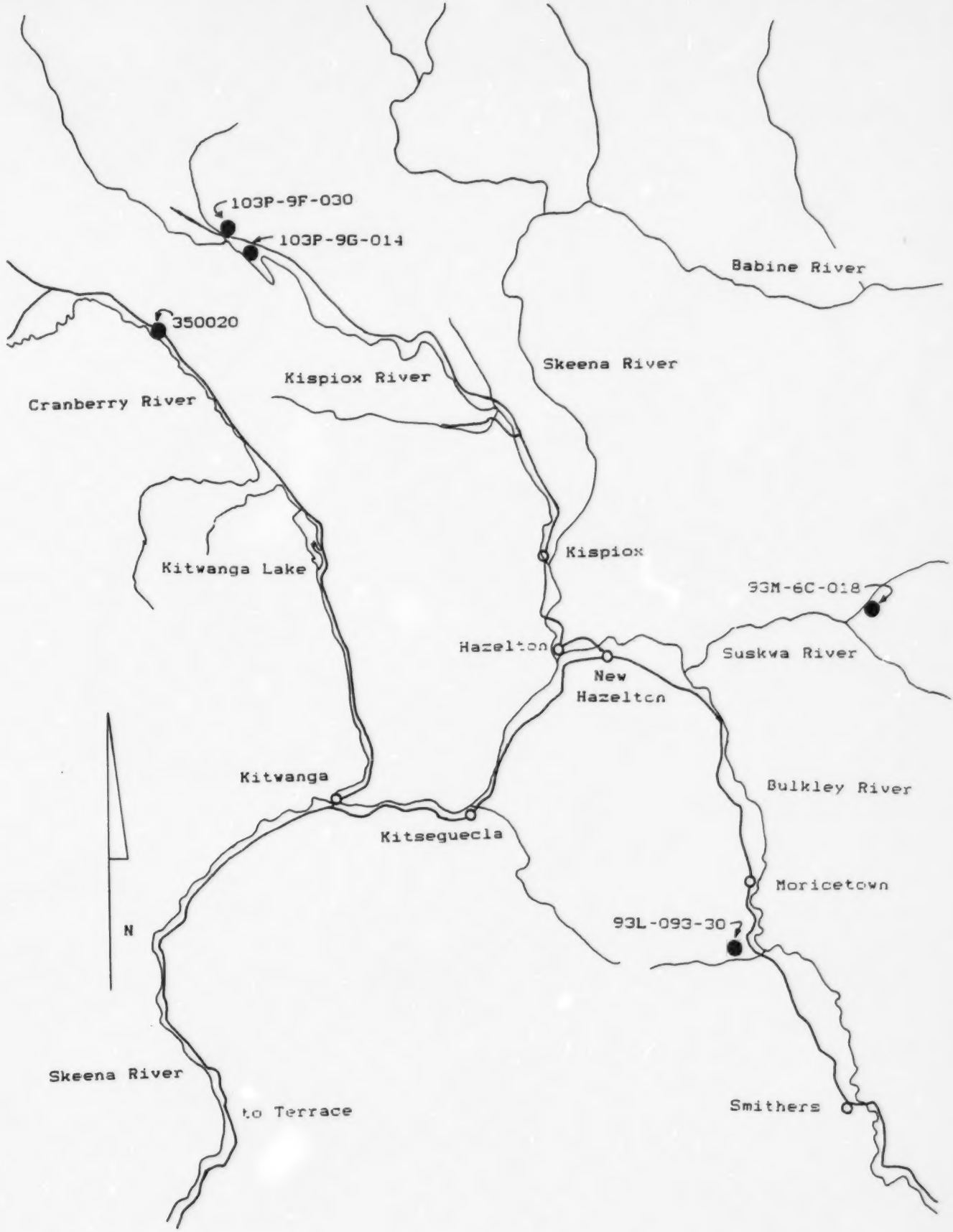
OTHER:

| BEARING (AZIMUTH) | PLOT NO | E.A. NO | LAYER | TOTAL TREES | TOTAL CONIFERS | SPECIES | TOTAL W | TOTAL FG | LEADER HT. (cm) | TOTAL HT. (cm) | AGE (yr.) | PLANTABLE | PREPARABLE | DIFFICULTY | OTHER | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PLANTED | | | | | | | | | | | | | |
| | | | NATURAL | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

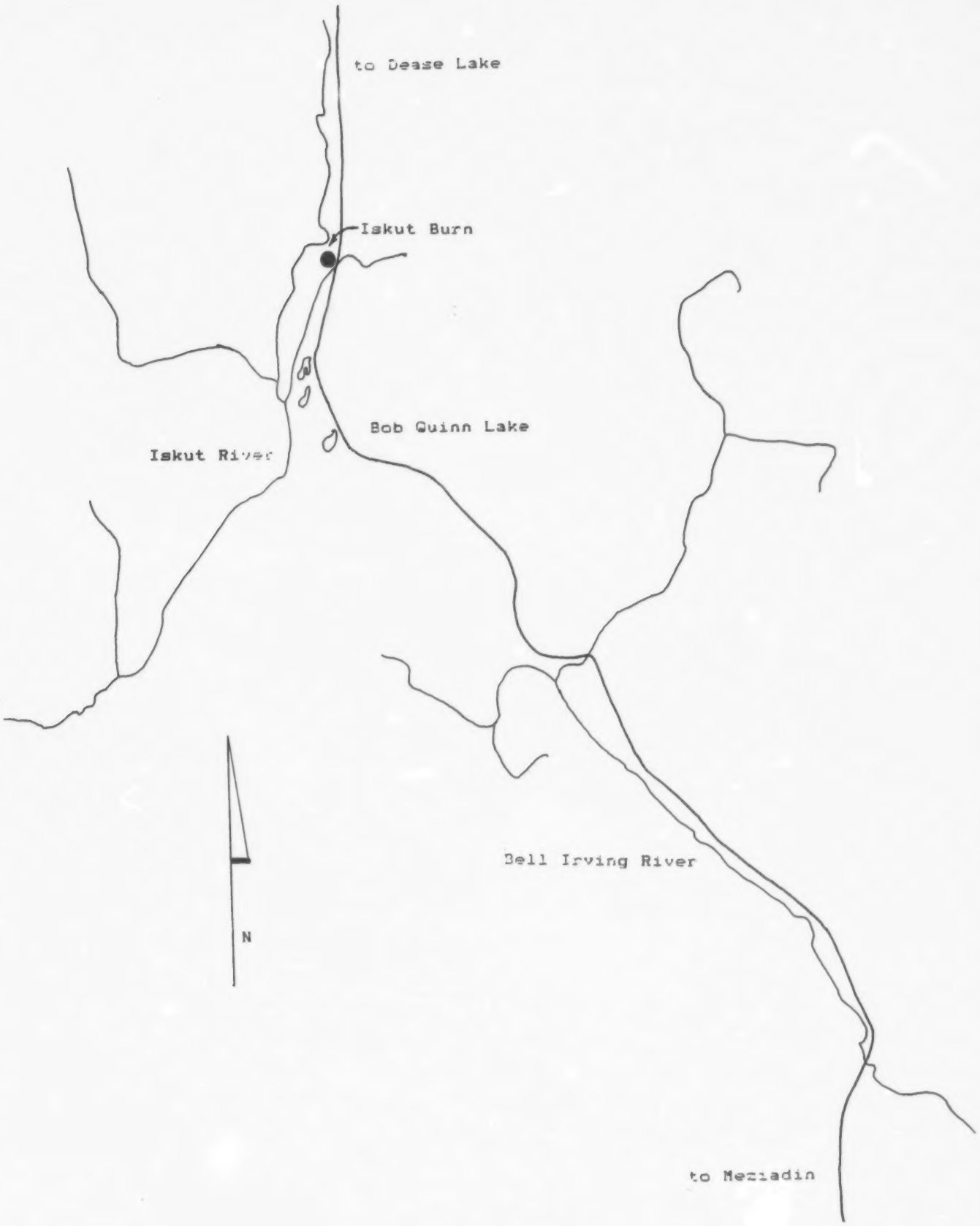
Comments on efficacy; rehab treatments; other:

# APPENDIX 5

# DEMONSTRATION SITES


103P-9F-030
103P-9G-014
Babine River
350020
Skeena River
Kispiox River
Cranberry River
Kitwanga Lake
Kispiox
93M-6C-018
Hazelton
Suskwa River
New
Hazelton
Kitwanga
Bulkley River
Kitseguecla
Moricetown
93L-093-30
N
Skeena River
to Terrace
Smithers

to Dease Lake
Bell Irving River
to Stewart
Meziadin
Meziadin Lake
N
Nass River
Kispiox River
103P-15C-010
103P-9F-030
103P-9G-014
Kinskuch River
350020
Cranberry River
317805
Alice Arm
317825
to Kitwanga
New Aiyansh
Nass River
to Terrace


to Dease Lake
Iskut Burn
Bob Quinn Lake
Iskut River
N
Bell Irving River
to Meziadin

**District**: Bulkley
**Opening #**: 93L-093-030
**Subzone**: ICHg3

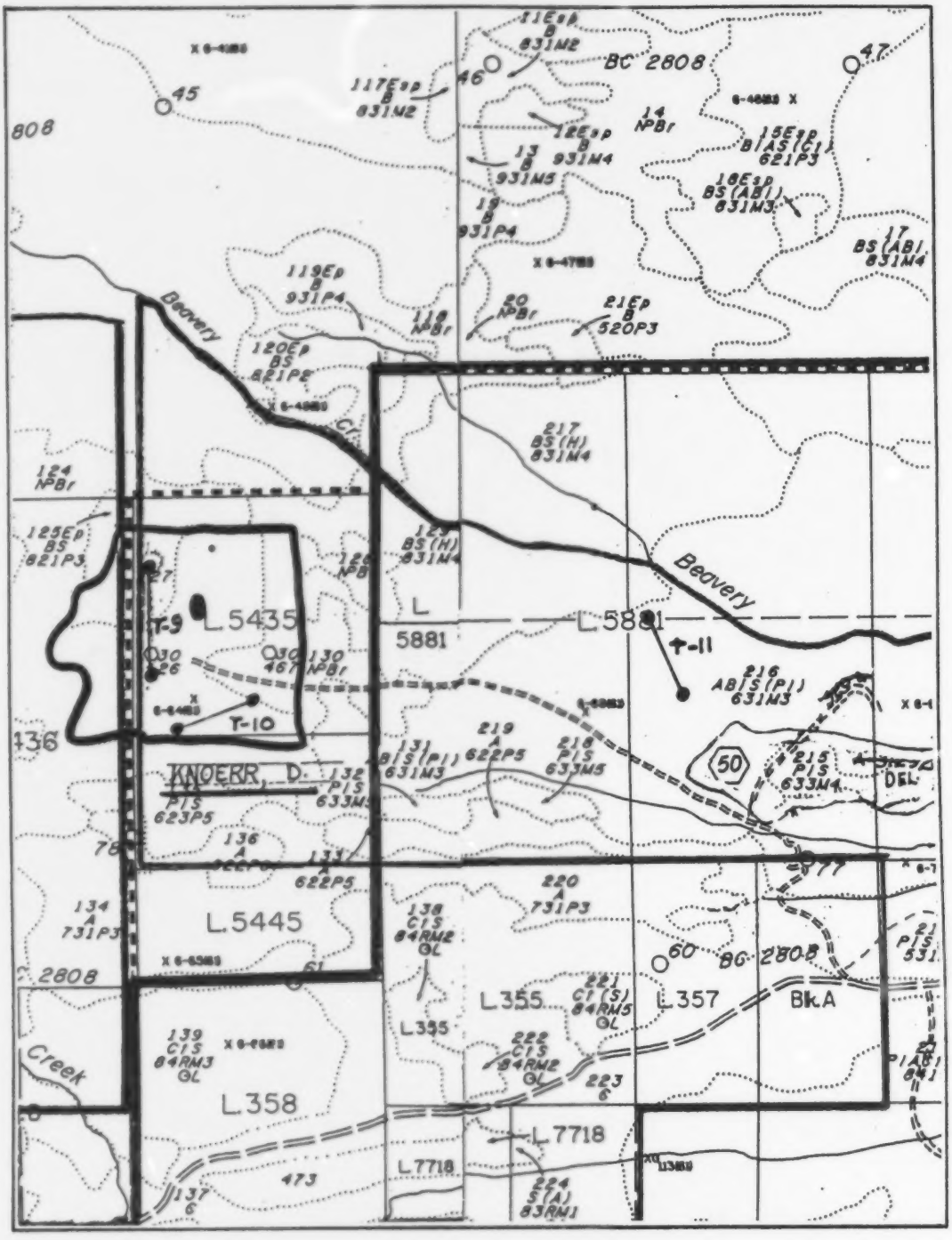
**Access**: From Smithers drive north to the Kitsegeucla Lake Road. Turn left onto the road, cross the cattleguard and take the first right through the wire cattle fence. Follow this side road through the new logging until the FRDA sign and another wire cattle fence. The opening is on the far side of the fence.

**Site History**:
Logged 1974
Mechanical Site Preparation - trails - 1982
Plant May 1983, Sx
Survey June 1985, 24 ha NSR

NSR Windrowed Sept. 1986
Planted June 1987, Sx

**Reforestation Problem**: This is a brushy site which after initial site preparation did not receive a brush treatment. Regeneration failure appears to be due to vegetation press and competition for light. It does not appear that the cows are a problem as less than 1% of the seedlings were trampled. The grazing does limit chemical brush control.

Poor stock quality or drought at the time of planting also contributed to the initial plantation failure.




District: Bulkley
Opening #: 93L-093-030
Scale: 1:20 000

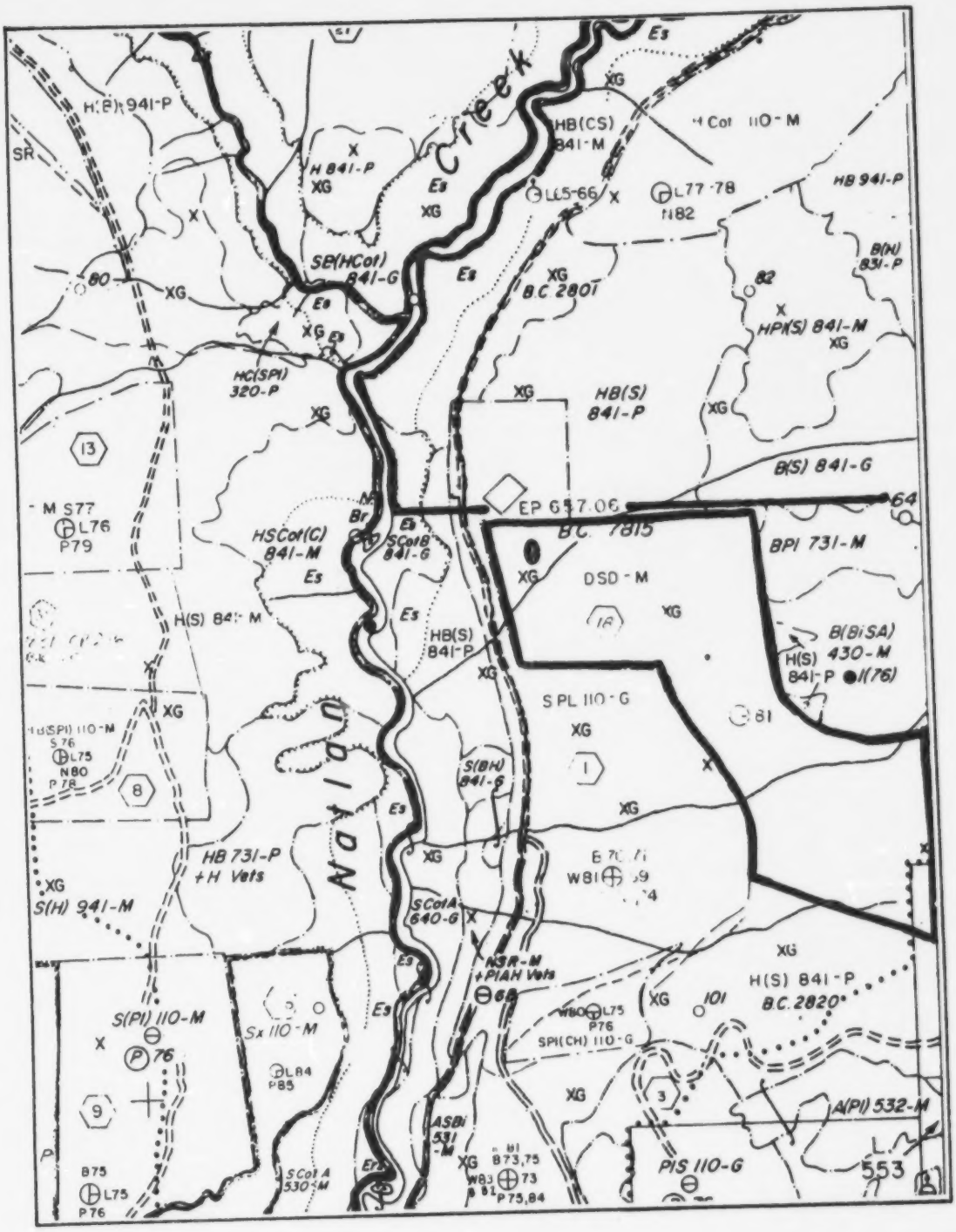
**District:** Kispiox
**Opening # :** 93M-6C-018
**Subzone:** ICHg3

**Access:** Drive east along Highway 16, from Hazelton to the Suskwa River Forest Service Road. Turn left onto the Suskwa River Forest Service Road, continue until the Natlan Creek junction at 14 km and take the left fork. Follow the Natlan Creek Road for 3.5 km, the opening lies to the east above the road.

**Site History:**
Logged 1981
Mechanical Site Preparation - trails - Oct. 1985
Planted Sept. 1986, Pl/Sx
Survey Sept. 1987 - NSR

**Reforestation Problem:** This area was site prepared resulting in deep trails to the mineral horizon. It was noted that the growth of seedlings off the trails was slightly better than those on the trails. Site preparation would have increased planters access through the thick humus and brush, however, high impact MSP is felt to have reduced the moisture and nutrient availability for seedlings planted on the trails therefore reducing reforestation success.

Initially site preparation must have reduced the brush though brush levels are now moderately high. Lack of an immediate follow-up brush treatment has also increased the reforestation problem. Vegetation competition for light, nutrients and physical space off the trails is contributing to seedling mortality.




District: Kispiox
Opening #: 93M-6C-018
Scale: 1:20 000

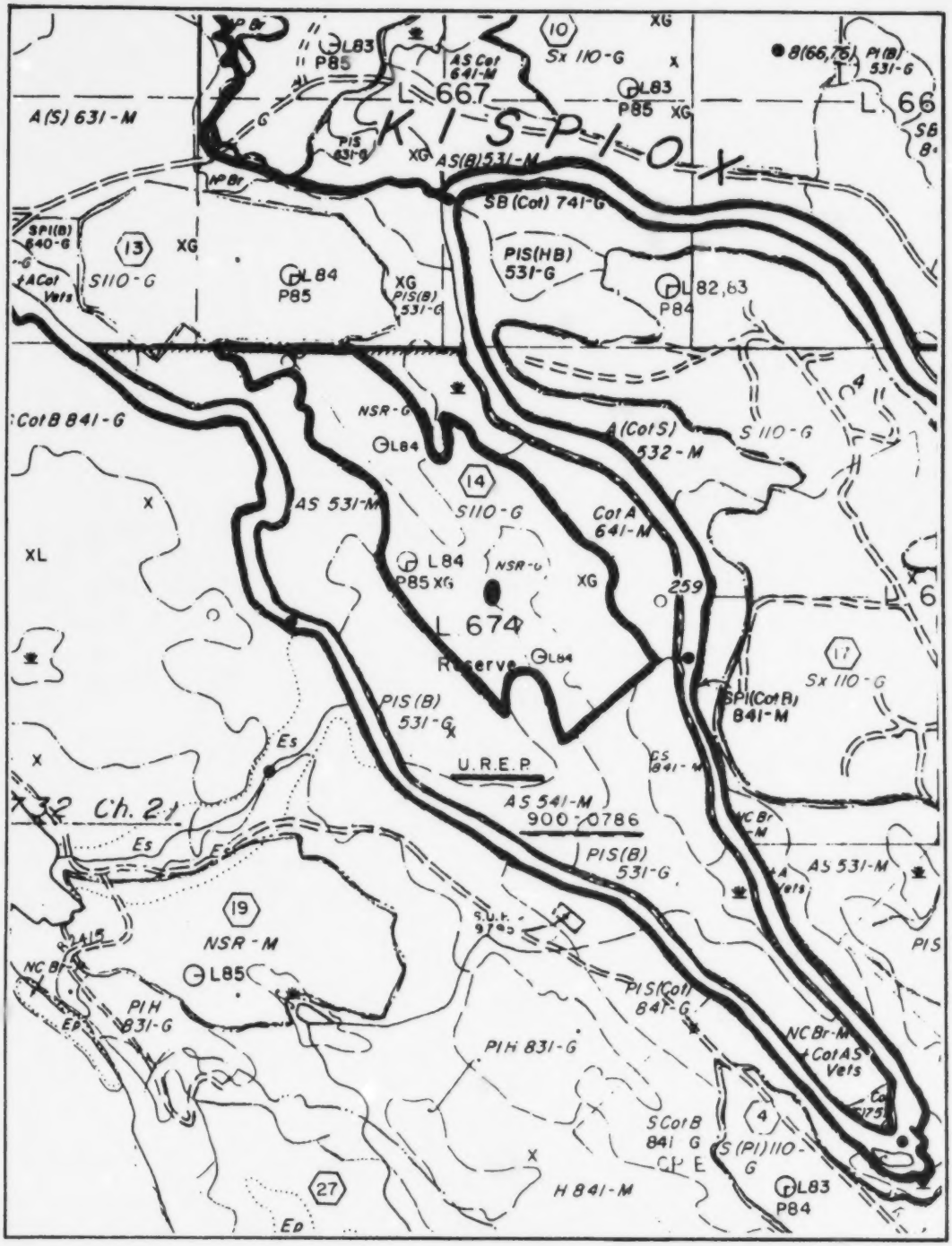
**District:** Kispiox
**Opening #:** 103P-9G-014
**Subzone:** ICHg3

**Access**: From Hazelton drive north to the Kispiox Forest Service Road. Drive out the Kispiox Forest Service Road to 24 km and turn left onto a side road. If you reach the Sweetin Campsite return 1 km. Drive down the side road and continue until the second opening, this is opening 103P-9G-014.

**Site History**:
Logged 1984
Planted August 1985, Sx
Survey Fall 1986, areas of NSR

**Reforestation Problem**: Seedling failure in the first growing season has resulted in patchy NSR. Better survival occurred on the NE slopes than on the SW slopes. It is felt that drought at the time of planting, due in part to summer planting on mesic and drier sites, contributed to seedling mortality.

On some of the sites spruce is marginally acceptable according to the Insert 11 Prince Rupert Forest Region Silvicultural Standards. Potential for future moisture and nutrient stress is possible.




District: Kispiox
Opening #: 103P-9G-014
Scale: 1:20 000

**District:** Kispiox
**Opening #:** 103P-9F-003
**Subzone:** ICHg3

**Access**: From Hazelton drive north to the Kispiox Forest Service Road. Drive out the Kispiox Forest Service Road to 25 km, just past the Sweetin Campsite. The opening lies on the north side of the road.

**Site History**:
Logged 1984
Planted May 1985, Sx
Survey fall 1986, 11 ha NSR
Chemical brush and weed August 1987
Replanted June 1988, Sx and Cw

**Reforestation Problem**: The area that is NSR is a rocky depression. The existing stocking has poor performance, and high (20%) frost and aphid damage.

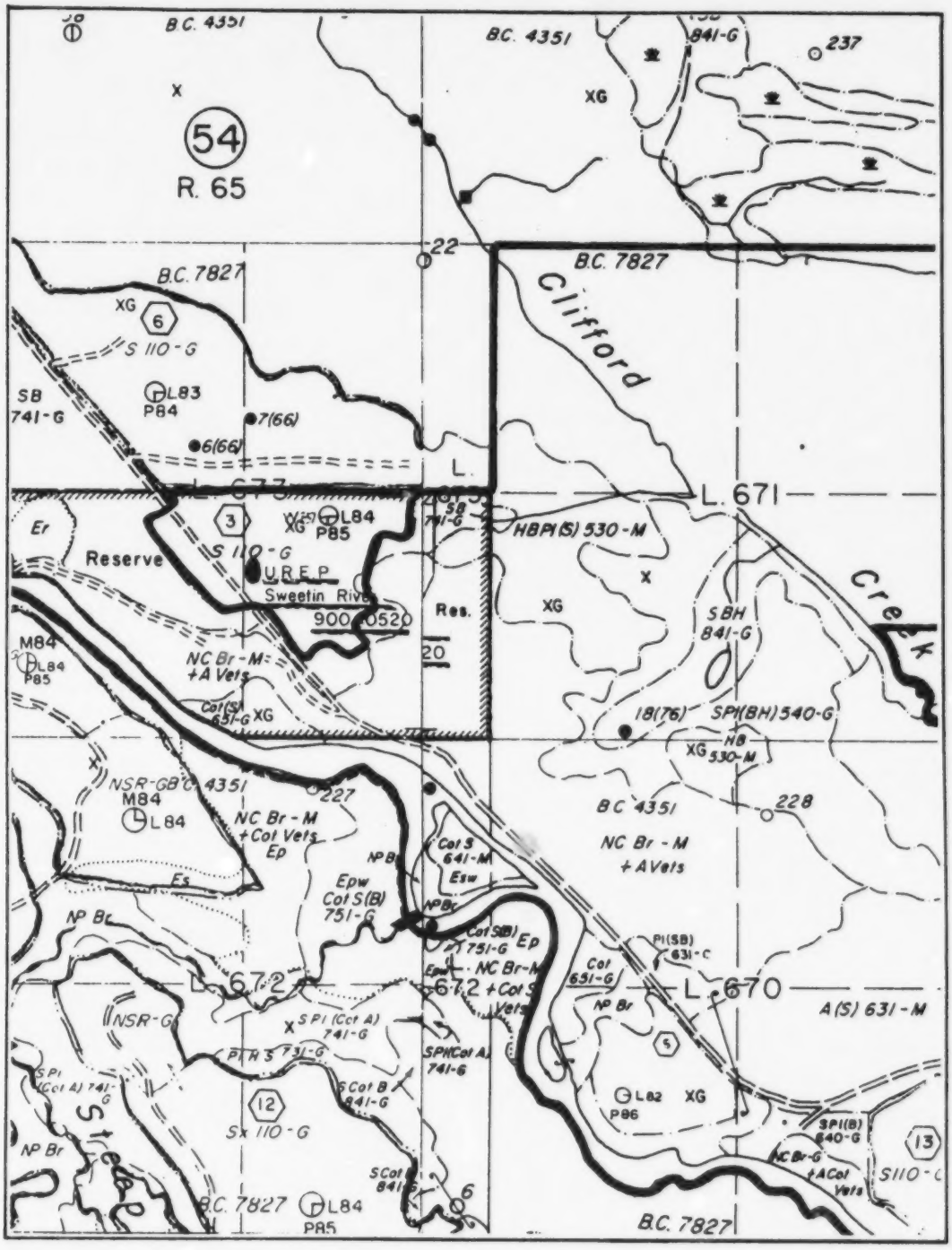
Cold soils are the main factor contributing to reforestation failure and result because of a thick LFH, cold air ponding, and the poor drainage. Alternative treatments for this site include the use of mechanical site preparation techniques, such as mounding or ripping, to increase soil warming and drainage.

The frost damage noted could be associated with poor acclimatization of the spruce stock. High aphid attack may be associated with the low resistance of the Sx stock.

The herbicide application is unlikely to have a pronounced impact on seedling survival and performance since:

1. high levels of grass have developed in place of brush species;
2. soils are a more important limiting factor.

On these types of sites small units may require special treatment regimes. The site heterogenity should be reflected in the PHSP and appropriate prescriptions provided.




District: Kispiox
Opening #: 103P-9F-003
Scale: 1:20 000

**District:** Kispiox
**Opening #:** 350020
**Subzone:** ICHg2

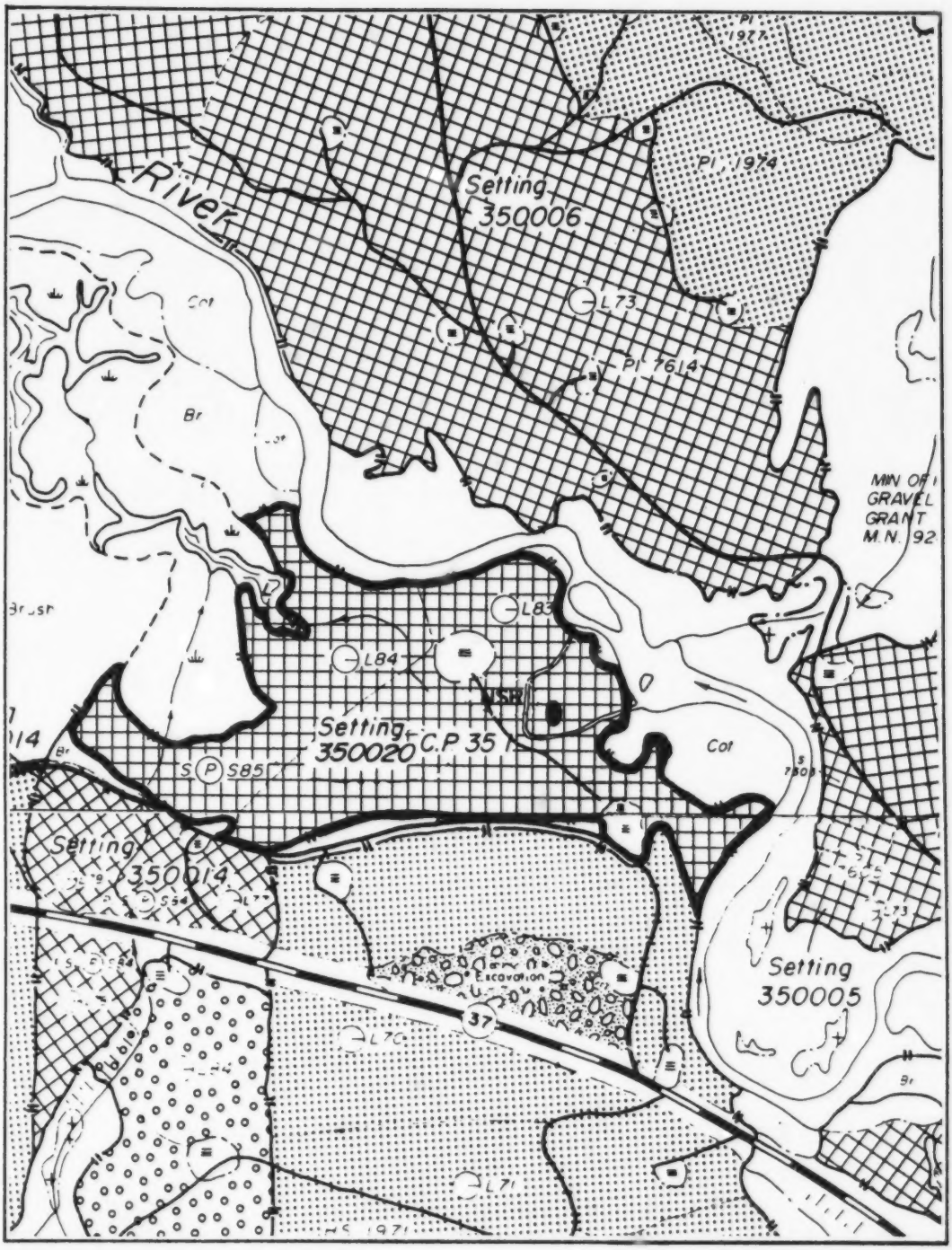
**Access:** From Hazelton drive west along Highway 16 to Kitwanga and then north on Highway 37. Drive 71 km on Highway 37 then turn off to the right onto a side road at the edge of the Ministry of Highways gravel pit. Follow this road towards the Cranberry River. The opening is located at the end of the road.

**Site History:**
Logged 1983-1984
Mechanical Site Preparation April 1985
Planted June 1985
Survey May 1987, NSR

**Reforestation Problem:** Most of the planted spruce on this site have multiple tops due to frost damage which occurred during initial establishment.

Site features, such as its location at the bottom of a U-shaped valley and the line of timber along the lower edge (reducing cold air movement), should have been used to identify the potential for frost damage and frost resistent stock planted accordingly.

Brush competition is also contributing to poor performance and survival. Heavy grass competition and a variety of shrubs exist on the site. Planting larger stock and/or an earlier brush treatment may have been beneficial on this site.




District: Kispiox
Opening #: 350020
Scale: 1:20 000

**District**: Kalum
**Opening #**: 317805
**Subzone**: ICHg1

**Access**: From Terrace drive north through New Aiyansh to Nass Camp. From Nass Camp continue along this road for 10 km. Turn left up a main haul road and continue along for 12.5 km. Turn left and follow this road south for 1.5 km. The opening is located to the left of the left fork of the junction.

**Site History**:
Logged 1981
Planted 1985, Sx
Survey May 1987 NSR

**Reforestation Problem**: This site has spotty regeneration with some natural fill-in. This is a difficult site to manage with its combination of rocky shale ridges interspersed with sites of deeper soils. An insufficiently detailed planting prescription resulted in approximately 40% of the spruce trees being planted "off-site" (ie, they are not on acceptable ecosystem associations). Spruce on these rocky crests are under moisture stress and are doing poorly. Possibly drought at the time of planting and poor planting quality on these shallow soils have also contributed to failure on this site. Spruce on lower slopes are experiencing competition for light and would benefit from follow-up brush treatment.

**District**: Kalum
**Opening #**: 317825
**Subzone**: ICHg1

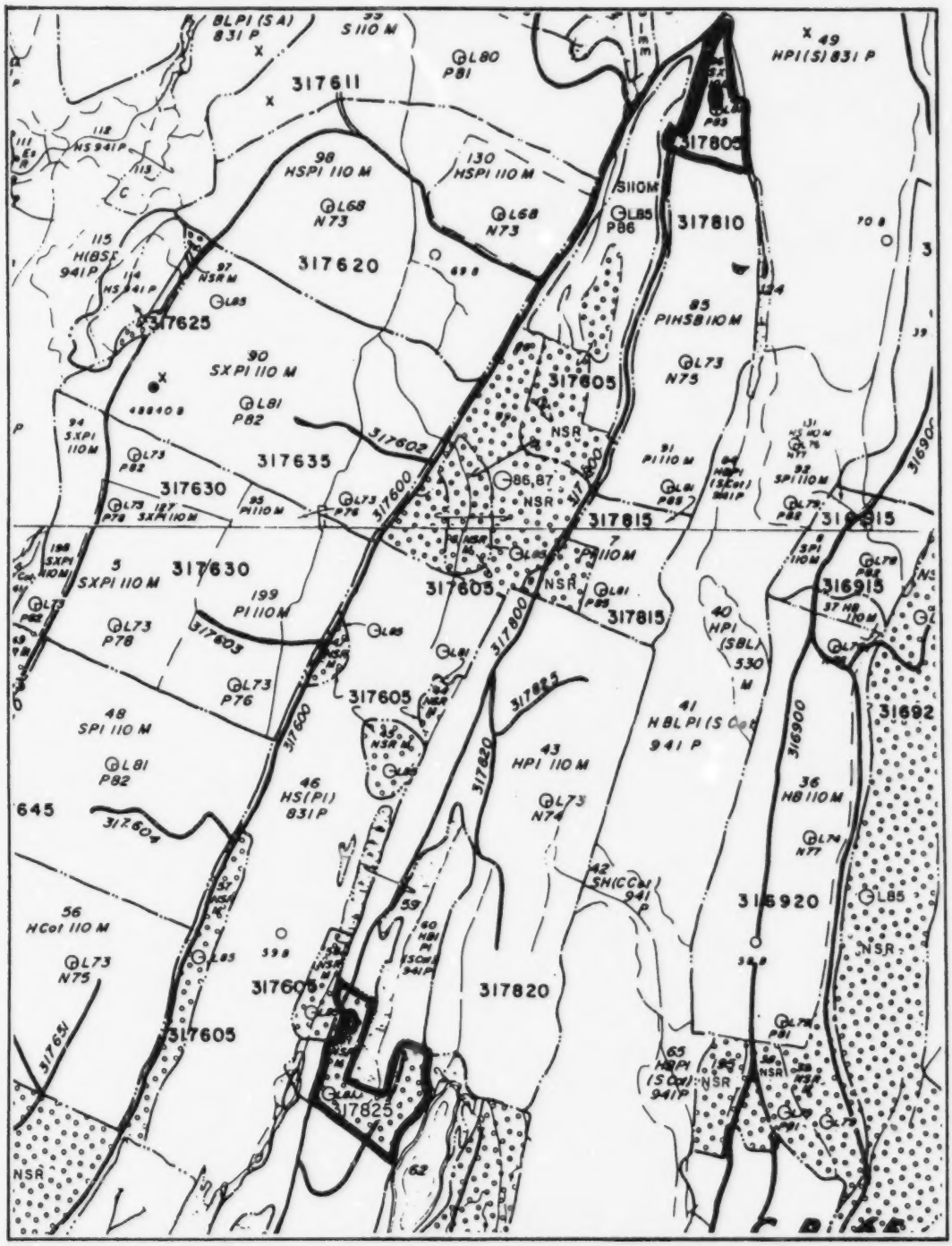
**Access**: From Terrace drive north through New Aiyansh to Nass Camp. From Nass Camp continue along this road for 10 km. Turn left up a main haul road and continue along for 12.5 km. Turn left and follow this road south for 1.5 km. At the junction take the left fork for 3.5 km at which distance you enter the opening.

**Site History**:
Logged 1981
Survey May 1986 NSR

**Reforestation Problem**: This site has 186 well spaced stems of natural regeneration. Stocking levels are low because:

- advance regeneration is comprised of unacceptable species;
- cones were removed from the site during harvesting activities;
- few mature Pl trees are adjacent to the opening and potential seed-in is limited; and
- no treatments were undertaken to improve the seedbed

Fortunately brush hazard is low reducing the risk and cost of crop establishment at a later date.




District: Kalum
Opening #: 317805; 317825
Scale: 1:20 000

**District**: Kalum
**Opening #**: 103P-15C-010
**Subzone**: ICHg1

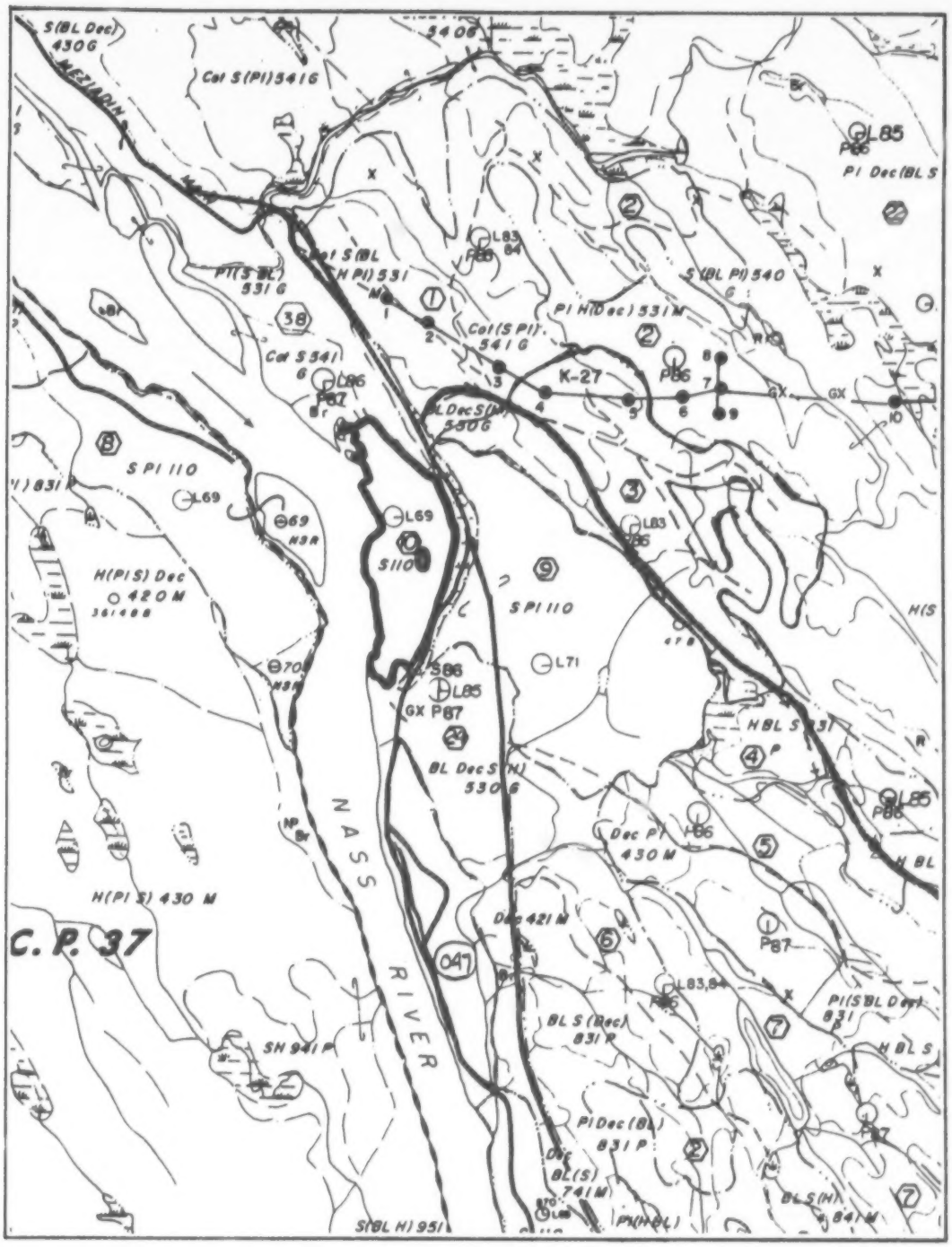
**Access**: From Terrace drive east along Highway 16 to Kitwanga. Then take Highway 37 north for 105 km. The opening is located on the west side of the highway, adjacent to the Nass River.

**Site History**:
Logged 1969
Planted 1969, Sx
Survey 1969, SR
Survey 1987, NSR-Br

**Reforestation Problem**: This is a high brush hazard site (E.A. 05) and hasn't received any follow-up treatments after planting. Although initial establishment appears to have been successful, subsequent mortality occurred through competition for light and vegetation press.

An important factor to note is that on the few surviving spruce heavy *Pissodes strobi* attack is occurring. The potential for the weevil to be a major problem in spruce plantations in the area should be recognized.

On this fluvial site Ac management or mixed wood management could be considered to reduce the costs of brush control.




District: Kalum
Opening #: 103P-15C-010
Scale: 1:20 chains

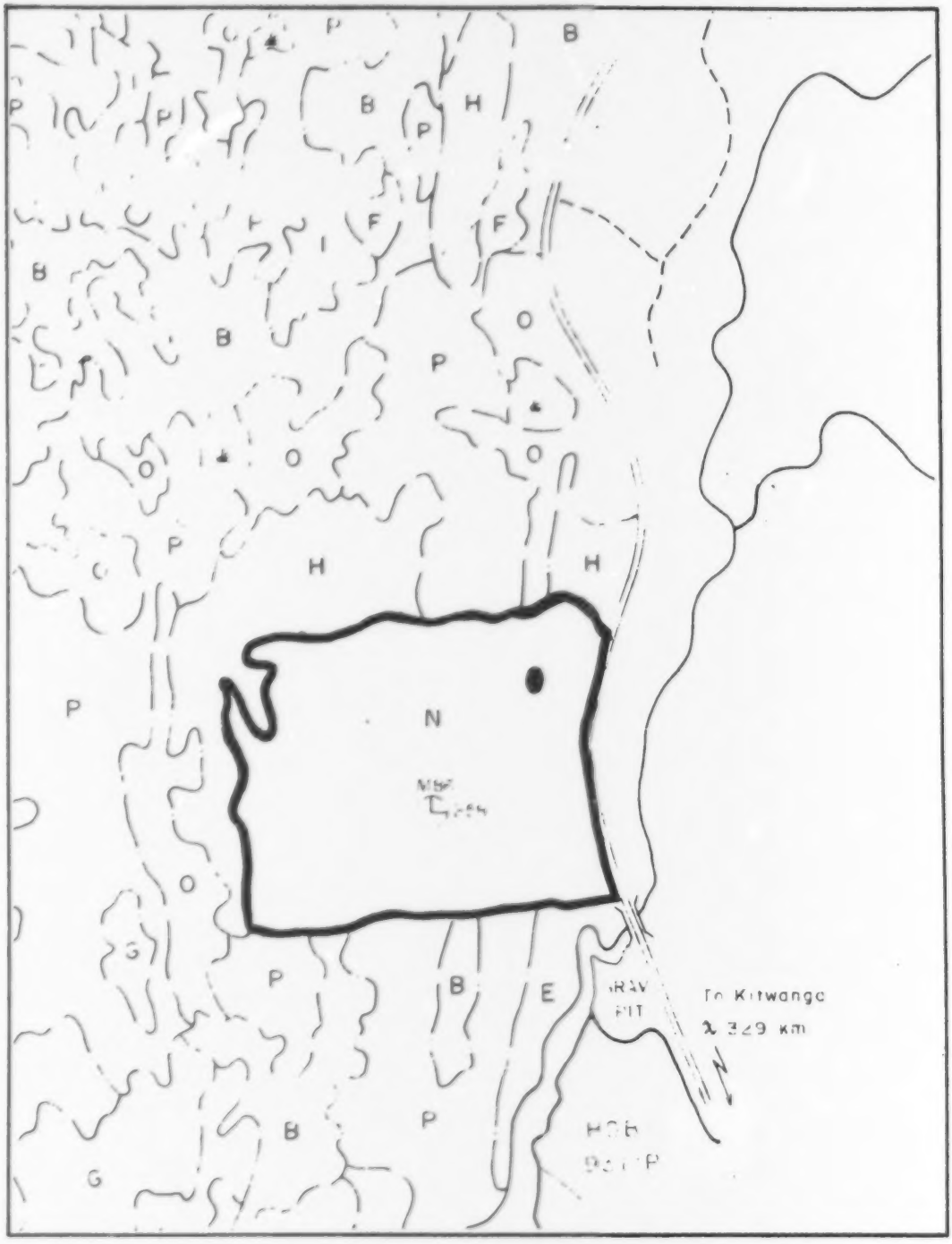
**District:** Cassiar
**Opening #:** 104G-1W-07, Iskut Burn, Strata N
**Subzone:** ICHg5

**Access:** From Kitwanga drive north along Highway 37, past Meziadin for 329 km. The area that is site prepared is located on the west side of the highway just past the bridge crossing Thomas Creek.

**Site History:**
Wildfire 1958
Mechanical site preparation - trails - 1986
Free growing survey 1987
Planted Spring 1988

**Reforestation Problem:** Mechanical site preparation damaged much of the established regeneration on this unit and promoted willow suckering. As a result, brush control will soon be required. On this site, longer term consequences were ignored in order to achieve the immediate objective of improving planter access. Treatment decisions should be based on the cost of the entire regime rather than individual phases. It may have been more appropriate to direct plant, eliminating site preparation costs and reducing brush control costs, or to use a brush blade when soils were not frozen to uproot the willow.

Alternatives to herbicides need to be developed in this District where public pressure and high fish and wildlife values limit the use of such brush treatments.




District: Cassiar
Opening #: Iskut Burn; 104G-1W-07
Scale: 1:10 000